SCIENCE

11 March 1960

Vol. 131, No. 3402

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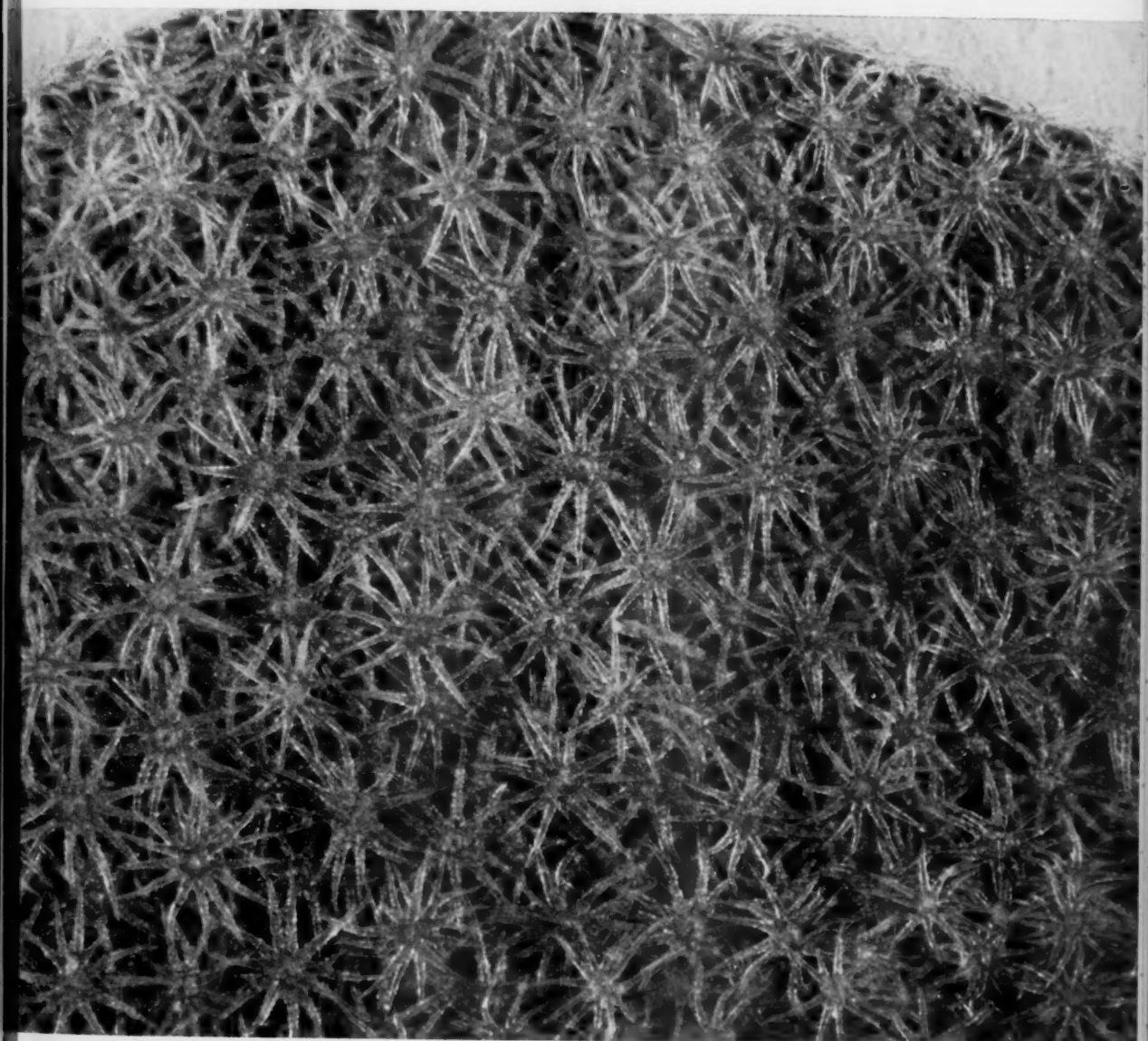

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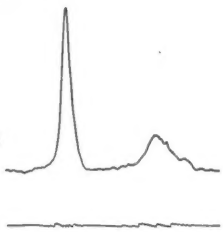

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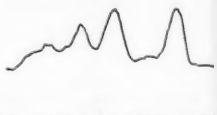

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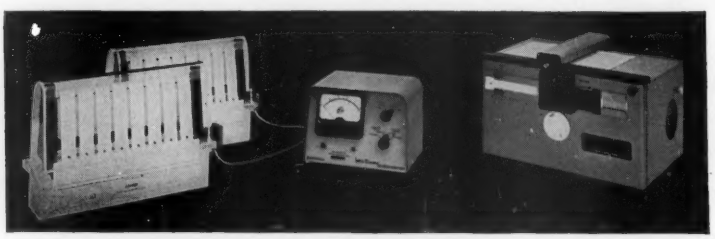

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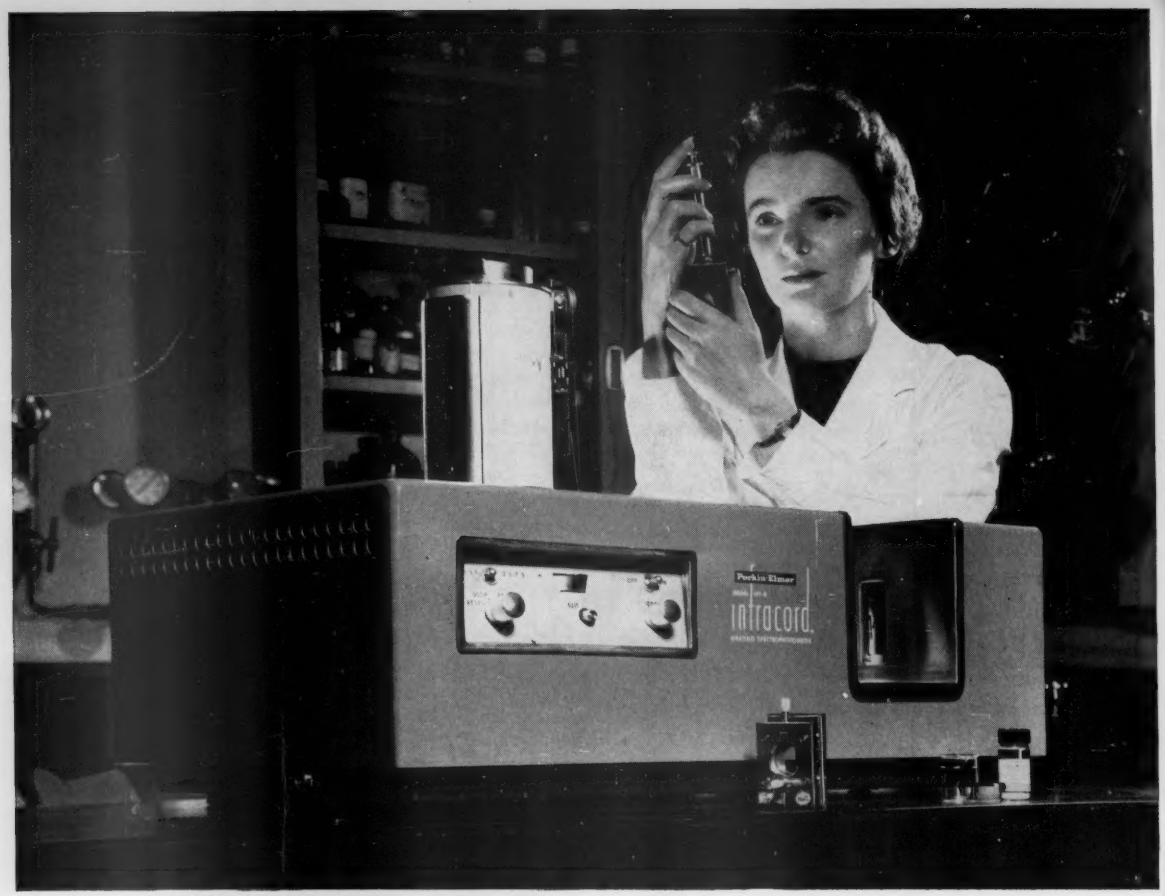

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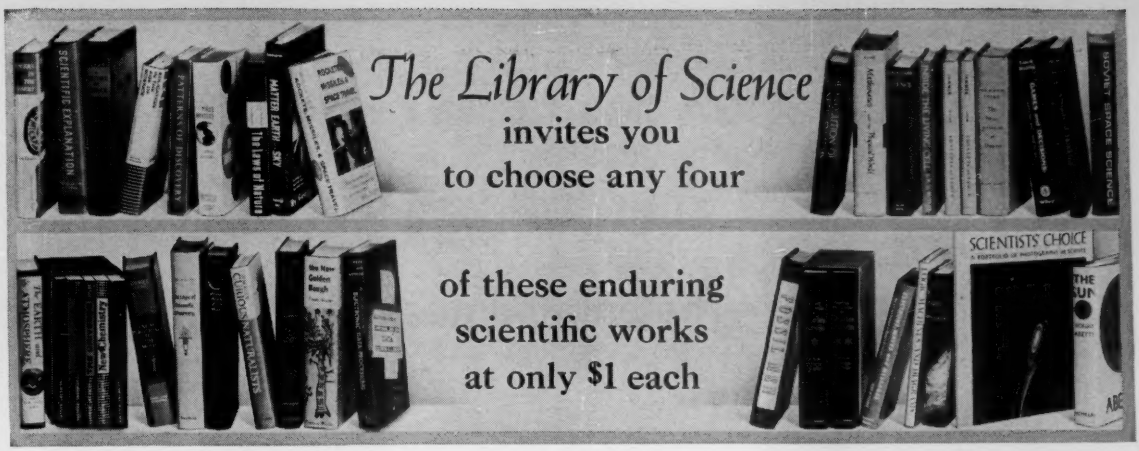

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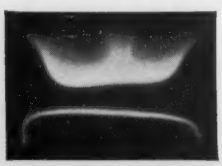

Iron carbonyl, an antiknock

Ethyl nitrate, a proknock

Iron carbonyl retards, ethyl nitrate accelerates central portion of cool flames.

Letters

The Moon Illusion

In the paper entitled "Magnitude of the moon illusion as a function of the age of the observer" [*Science* **130**, 569 (1959)], H. Leibowitz and T. Hartman stated, "The diminution in the apparent size of an object when viewed overhead as compared with its apparent size in the horizontal plane is greater for children than for adults." They suggested in explanation, "Since children have less experience with distantly viewed objects, especially when viewed directly overhead, the magnitude of the moon illusion is greater the younger the observer." One is not justified, I believe, in assuming that the horizontal "moon" is correctly perceived while the perception of the overhead moon is in error. It is just as reasonable to assume that the size of the overhead "moon" is correctly perceived but the horizontal "moon" is erroneously perceived as being larger than actual size. In this case the explanation of more experience with horizontal objects and therefore better accuracy in judging their size would be contradicted by the experiments of Leibowitz and Hartman.

Furthermore, since some visual cues occurred in these experiments, even in the darkened but not completely dark theater, the explanation of the moon illusion referred to by Thomas Reid seems more credible. "We frequently perceive the distance of objects by means of intervening or contiguous objects, whose distance or magnitude is otherwise known. . . . An object placed upon the top of a high building, appears much less than when placed upon the ground, at the same distance. When it stands upon the ground, the intervening tract of ground serves as a sign of its distance; and the distance, together with the visible magnitude, serves as a sign of its real magnitude. But when the object is placed on high, this sign of its distance is taken away: the remaining signs lead us to place it at a less distance; and this less distance, together with the visible magnitude, becomes the sign of a less real magnitude. Dr. Smith hath observed, very justly, that the known distance of the terrestrial objects which terminate our view, makes that part of the sky which is towards the horizon appear more distant than that which is towards the zenith. Hence it comes to pass, that the apparent figure of the sky is not that of a hemisphere, but rather a less segment of a sphere. And, hence, likewise, it comes to pass, that the diameter of the sun or moon, or the distance between two fixed stars, seen contiguous to a hill, or to any distant terrestrial object, appears much greater than when no such object strikes the eye at the same time" [T. Reid, *The Works of Thomas Reid, D.D.*, W. Hamilton, Ed. (Longmans, Brown, Green, and Longmans, London, new ed., 1846), sec. 22].

Lastly, the increase of the illusion with distance of the object from the eye may be due to the loss of significant information for depth perception which might ordinarily arise from the ciliary muscles of accommodation. This is reasonable because the adjustments of the ciliary muscles for objects at distances greater than about 30 feet appear to be insignificant.

LEONARD A. COHEN
Department of Physiology and Pharmacology, University of Pittsburgh, Pittsburgh, Pennsylvania

The point raised by Cohen in the first paragraph of his letter has previously been discussed [*Science*, **131**, 238 (1960)].

The point raised by Thomas Reid's explanation is logical but was not supported by the verbal reports of our subjects. Most of them expressed surprise when they were informed, after completion of the testing, that the overhead and horizontal stimuli were in fact at the same distance. Their opinion was that the overhead disk was farther away than the horizontally viewed comparison stimuli. Furthermore, the building from which the overhead disk was supported provided a number of cues to distance—for example, perspective and relative size—which were not present to the same degree for the horizontal stimuli. It would seem that the judgment of distance does not influence size judgments in a direct or simple manner.

If the change in the magnitude of the illusion were directly dependent on loss of information from the ciliary muscle, one would expect no further increase at distances beyond 20 or 30 feet. The data of Schur, referred to in our original article, would argue against Cohen's interpretation, for she discovered that the magnitude of the effect was influenced by variation of distance beyond this point.

H. LEIBOWITZ
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Zero Tolerance

At a date still to be set for sometime next month, the House Committee on Interstate and Foreign Commerce will assemble a panel of scientists for hearings on food additives. The use of cancer-inducing substances (carcinogens) as food additives, which has been brought prominently to public attention by the recent cranberry incident and the barring from the market of fowl treated with a synthetic female sex hormone that can induce cancer under laboratory conditions, will undoubtedly be a major issue.

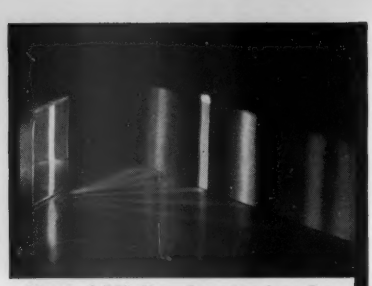
Central to this issue is the controversial "Delaney clause" of the 1958 amendment to the Food, Drug and Cosmetics Act, which prohibits the use as a food additive of any substance that "is found to induce cancer when ingested by man or animal, or if it is found, after tests which are appropriate for the evaluation of food additives, to induce cancer in man or animals. . . ." The effect of this clause is to put carcinogens in a different category from that of other toxic substances. For such other substances, tolerances may be established after appropriate testing or on the basis of long experience with their use in foods. But the Delaney clause, as it has been interpreted by Secretary Flemming of the Department of Health, Education, and Welfare, sets a "zero tolerance" for any substance that can be shown to induce cancer when fed to animals in any amounts over any period of time. Opponents of the clause in the food and chemical industries, and many scientists who have no industrial axes to grind, call the clause "unworkable" and "unrealistic." They contend that the clause prevents the exercise of scientific judgment about safe levels of carcinogens in foods.

Those scientists and others who favor the Delaney clause justify putting weak carcinogens—strong carcinogens are not in question—in a special category on several grounds. Weak carcinogens usually take a long time to have an effect, and even then they induce few cancers. Furthermore, in the present state of our knowledge, it is not possible to say with absolute assurance that even a small dose of a weak carcinogen will not initiate irreversible cellular changes that may lead to the formation of cancer in man long after exposure.

For an ordinary toxic substance, the effects are rapidly manifested and are reversible. Consequently, thresholds of action for an ordinary toxic substance in animals can be readily determined, and the limit for human consumption can be set at some small fraction (1/100 or less) of the no-effect level for the most susceptible animals tested.

For a weak carcinogen, on the other hand, the long latent period and the infrequency of response make the determination of a threshold far more difficult: many more animals must be treated for much longer periods before reasonable estimates of hazards may be made. The task is difficult, but surely not impossible. What is needed is far more systematic animal experimentation with weak carcinogens, administered orally and in amounts that suffice to establish dependable dose-response relations.

These considerations and others too complex to be considered here will give the scientific panel a difficult job. We hope the panel will be able to suggest the most effective means of bringing scientific judgment to bear upon the provisions of the Delaney clause.—G.DuS.



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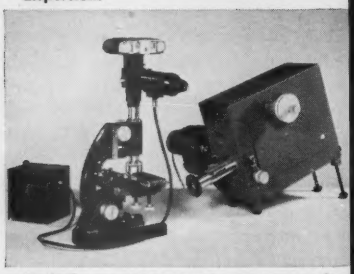

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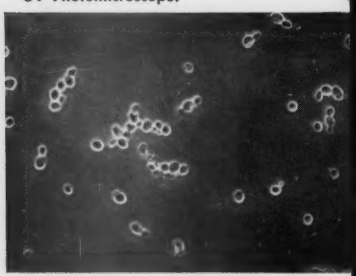

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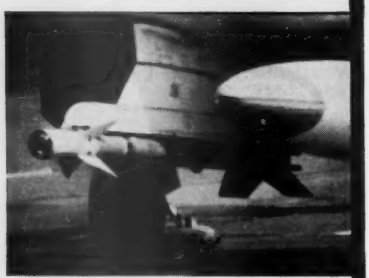

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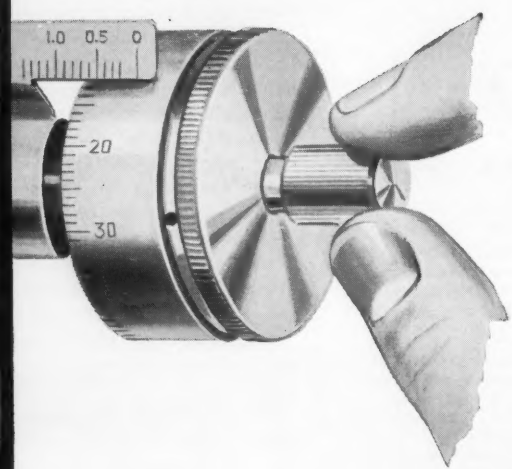

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11 March 1960, Volume 131, Number 3402 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Blood Groups of the Ancient Dead

Paleoserology has provided a new tool for the anthropological study of gene flow in the past.

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The blood groups of the dead have been of interest primarily in medicolegal fields. Landsteiner and Richter had already, in 1903, surveyed the possible use of blood-group data in forensic medicine (*1*); it is probable that the first application, in this field, of knowledge of the reactions of the blood was by Lattes in 1916, when he presented evidence on blood stains before an Italian court (*2*). The techniques first developed allowed distinction to be made only between human and nonhuman blood, but with subsequent improvements, and the discovery of groups other than the ABO antigens, the value of such evidence has increased enormously, and much further research has been done.

The anthropological applications of statistics on blood groups of the living are well known, and such statistics have been put to widely increasing use since the original discovery of the Hirszfelds in 1919 (*3*). The pattern of frequencies varies considerably from one population to another, and deductions on racial origins and degrees of affinity have been shown to be valuable; indeed, in some respects they are superior to the metrical characters of the early anthropologists, because they appear to be less subject to the fluctuations of environment. It is natural that interest should have extended to work on historical and archeological material, in an attempt to compare the distribution of blood groups among the living with that among their ancestors. The techniques used owe much both to medicolegal research and to the interest of biochemists in the occurrence of blood-group substances in body tissues and fluids.

The first application of these techniques was by William and Lyle Boyd (*4*). In 1933 they published a note on blood grouping by means of preserved muscle. This was followed by work on dried muscle and saliva, and then on Egyptian and American mummified tissues. Their choice of technique would appear to have been influenced by the work of Lattes on stains, and the method was highly successful on muscle, but its application to bone did not satisfy them, and it was left to Candela to develop methods suitable for cancellous bone, and to show that bone could give comparable results. The work of the latter in establishing that the blood groups may be identified in bone (*5*) is of wide significance to the anthropologist. Bones are relatively more abundant than preserved flesh, and survive under more varied conditions and to a greater age.

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These workers were attempting to identify the A and B antigens and also to show the presence of M and N. Matson (*6*) contributed experiments on the use of bovine anti-O sera on saliva, on muscle obtained at autopsy, and on mummified muscle. The idea of extending his work to bone does not appear to have occurred to him, in spite of the very encouraging results he obtained on other tissues. Recent authors, such as Thieme, Otten, and Sutton (*7*) and Laughlin (*8*), have applied these methods to particular problems and have attempted the solution of some of the difficulties outlined by the earlier workers. Recent use of paleoserological methods has been made in an attempt to distinguish between the rival skulls of Swedenborg (*9*). The attempt, although unsuccessful because of the occurrence of the same antigen in both skulls, shows an interesting use of these techniques in detective anthropology.

In an early paper the Boyds discussed the medicolegal applications of the blood grouping of tissues (*10*). The greater range of the possible applications of such blood grouping is well illustrated by the extensive interest felt amongst archeologists, historians, and anthropologists today. Anthropologists trained in paleoserological techniques are now working in four laboratories, two in the United States and two in Europe. For innovation these laboratories still rely heavily on the interest and cooperation of forensic medicine, but their basic technique continues to be that of the earlier workers already cited.

Technique

In their paper "Blood grouping in forensic medicine" (*10*), the Boyds describe the technique which, in its broader outlines, has become the principal tool of the paleoserologist. This is based on the standard inhibition test. It was made possible by the discovery that the blood-group substances are not confined to the red blood corpuscles but may be found extensively and

sometimes in greater concentration throughout the organs and body fluids. It is possible to demonstrate the presence of group-specific substances in, for example, saliva, by testing its power to inhibit the action of its corresponding agglutinins on fresh red cells in the standard red cell-serum agglutination test. Similarly, the Boyds showed that dried and ground muscle could be mixed with antisera of known group and could inhibit agglutination in later tests with red cells. At first, the initial mixture of tissue and serum was allowed an inhibition time, at room temperature, of 1 hour. Subsequent tests showed that a period of at least 24 hours, in the refrigerator, gave more satisfactory results. Too long a period of inhibition can sometimes produce nonspecific absorption.

The use of both naturally occurring and immune antisera was advocated very early, as a means of establishing controls on the reactions obtained. The number of antisera used is often governed by the amount of material available; ideally, no fewer than three of each specificity are used. This is important in that it cannot be guaranteed that all tissue samples will react uniformly with the entire range of antisera in the panel. Morgan (*11*) has drawn attention to the presence of "many different resultant macromolecules . . . in different individuals belonging to the same ABO group, for example group A, depending on the subgroup and Lewis genotype of the individual. Thus, one would not expect the secretions of all group A individuals to yield products which are identical in properties and chemical constitution." In this connection it is also advisable to obtain regular supplies of the same antisera from individuals, and to be thoroughly familiar with the behavior of these antisera. Pooled sera are not usually used; it is generally considered more valuable to deduce results from the reactions of a panel of individual sera. Type O serum was popular with some workers at first, but was later discarded because of the unequal strength of the anti-A and anti-B components. Dodd (*12*) has also shown that there is often a linkage between the two agglutinins, which results in lowering of the titer of both where genuine inhibition has affected only one. It is surprising, in view of the evidence against the use of this serum, to find it being advocated by Harley in 1944 (*13*). Unless the sera used show an approximately equal absorption power and avidity, they will not provide adequate comparisons on the inhibitory powers of any two tissue samples and will throw little light on the amount of blood-group substance present. While this point may have only minor medicolegal significance, it is of great interest to the anthropologist comparing survival rates of group-specific substances according to age and environment.

The titer of the antisera is determined throughout with the use of fresh 1-percent suspensions of A_2 and B cells from the same donors. The use of A_2 cells is recommended because they give the more sensitive reading of neutralization of the anti-A component, rather than of the anti-A_1 component (*14*). Buffered saline, containing 1 percent sodium azide as a preservative, is used as a diluent throughout.

After inhibition, which is usually carried out in 10- by 75-mm tubes, the samples are centrifuged to throw down tissue particles, and the supernatant is removed. This is then titrated in order to determine, by comparison with its previous titer, whether its strength has been affected by contact with the tissue sample. The Boyds suggested a titer of four tubes before absorption, and held that a satisfactory standard of inhibition would be the removal of agglutinins over these four tubes. In practice in this laboratory, a titer of three tubes is considered to be satisfactory, especially with weakly reacting samples. The Boyds noted the unreliability of a single test. Our practice is to repeat the test at least three times on any given sample with any one serum, in order to obtain a confirmation of the inhibition. Fresh material, or that containing a high proportion of organic matter, will show some absorption at the seventh or eighth test.

The quantity of tissue used in proportion to a given volume of serum is never a constant for a variety of samples. Various workers advocate the use of 0.5 gram or more. Boyd and Boyd (*15*) used only 0.08 gram of ground muscle to 0.3 milliliter of serum. The quantity of material available will often be the deciding factor. In this laboratory it is usually found convenient to begin tests with 0.2 gram of tissue to 0.4 milliliter of antiserum, and to make adjustment in further tests in accordance with the results obtained. This proportion is usually satisfactory, except in the case of very weakly reacting tissue samples. A volumetric technique is used for titration, the drop technique being regarded as less accurate (*14*).

Other Methods

Other methods have been used in an attempt to establish the presence of group-specific substances in tissues. Matson made use of a simple alcohol extraction on material of known group but discarded the method because of hemolytic effects. Since his paper appeared, extraction techniques have been perfected by biochemists seeking to purify and analyze the components of the blood-group substances (see *16*). These methods require relatively large quantities of a tissue or a body fluid containing a high concentration of group-specific substance. For the purposes of paleoserology, however, a highly purified product is not essential, and this field offers much promise if a technique can be evolved from this basis which is both simple and efficient for our needs. Margery Gray investigated this subject in 1952 (*17*). While her results were not conclusive, her work represents a first step in an interesting direction.

Other techniques present possibilities worthy of examination. In particular, modifications of the precipitin and Coombs (antiglobulin) tests would appear to be suitable for application to aged human tissue. Stains up to 60 years old have been identified as human by the precipitin test. This can provide an invaluable preliminary to typing for particular antigens. This technique, because it is valid for all tissue proteins, can also be applied successfully to extracts of bones. Work on the Coombs technique has been published by Allison and Morton (*18*) and by Ruffie and Ducos (*19*). Ducos (*20*) has shown the possibility of identifying a wide number of antigens in blood stains, for forensic purposes. His work should be followed up in paleoserology in order to discover the extent of its application to aged stains and tissues.

Investigations into a number of other techniques are also being carried out. Their main purpose is to examine the amount of organic matter remaining in tissue aged under varying conditions, to determine the rate of preservation of blood-group substances, and to evaluate different methods of biochemical assay in relation to these studies.

Environmental factors, first investigated by Thieme, Otten, and Wheeler (*21*), also pose a problem on which study is urgently needed. Expert advice on soil conditions and bacterial effects has made it possible to set up experiments in these fields. It will be several

years before these experiments mature. It is hoped that they will show the extent and nature of bacterial contamination. This is known to present well-defined problems, in that bacterial antigens have the power to inhibit agglutination in human sera in a manner closely similar to that of the A and B antigens. One theory on the solution of this problem is that analysis for rare sugar components of bacterial cell walls may show whether inhibition can be attributed to bacterial contaminants or not. The value of this theory has yet to be determined, but it would appear to offer at least a partial solution to the problem.

Stability of Antigens

The stability of antigens may also be influenced by soil type and *p*H, and by rain action. It must be concluded that tissues present in soil for a sufficient length of time will, depending upon the rate of decay (particularly of fats) allowed by the nature of the soil, have lost by leaching any water-soluble antigens originally present. It remains to be determined what length of time this process takes in, for instance, chalk as compared with clay soils, rainfall, drainage, and temperature all being taken into consideration. It is certain that autopsy material used for control and experimental purposes still contains quite a high proportion of blood, even after fat has been extracted. Some attempt should be made to leach this out artificially, if such material is to provide comparison with unknown burial material of any antiquity.

Bacteria have been shown to present other problems, in addition to reactions similar to those of A and B antigens. Iseki and Okada (*22*) and Iseki and Ikeda (*23*) have concerned themselves with the decomposition of A and B group-specific substances by bacteria. Watkins (*24*) has shown the presence of blood-group decomposing enzymes in a protozoan. Such action, while it deprives the mucopolysaccharide of its original specificity, appears to leave H specificity. This finding has been used to suggest that H substance acts as a precursor for the synthesis of A and B. If this is so, and enzymic degeneration of A and B allows the appearance of results closely similar to, if not identical with, those obtained with the H antigen, then the need for a positive test for group O becomes more urgent.

The difficulties in this direction become immediately apparent when one studies the effects of sera on fresh red-cell suspensions in standard laboratory diagnosis of blood group. Here, the use of unknown sera with known red cells shows positive reactions for group O, where the sera will agglutinate both A and B cells. But in the use of known (anti-A and anti-B) sera, positive reactions occur only with cells having the A or B antigen. The presence of group O cells is presumed where reactions are consistently negative. In identifying the group in tissue samples it is possible to use only this part of the technique, because of the rapid post-mortem degeneration of agglutinins. This cannot be satisfactory when the possibilities of antigen degeneration are taken into consideration. The desirability of a positive test for group O is well illustrated by the Boyds' work on remains of prehistoric American Indians (*25*); 226 individuals were typed for this series, and of these only 13 gave positive results for A or B or both. Morgan and Watkins (*26*) have shown that antisera which are preferentially active against group O cells are of two kinds, one, which they call anti-H, being inhibited by the saliva of group O secretors and the other, anti-O, not being so inhibited. In this laboratory, experiments have been carried out with these sera on tissues whose ABO (H) character has been determined ante mortem. Anti-H sera of plant and animal origin would appear to give results which differ from those of sera with an anti-O specificity. Naturally occurring human anti-O sera would appear to inhibit, clearly and potently, all group O material. The presence of agglutinins to other antigens does not appear to affect the action of the anti-O component, and thus the usefulness of this serum would appear to merit closer investigation.

Nonspecific Absorption

In typing any large series of aged human tissues, where a number of results are recorded as AB, a query must be raised. Nonspecific absorption of all sera may occur in such material. The causes are in general obscure but may sometimes be associated with particle size in bone, with mineralization, or with contamination. The presence of fat in material having a high organic content may sometimes be the cause. It would seem very probable that early attempts to group mummified tissues gave erroneous results because of the presence of embalming fluids, and the Boyds noted a number of anomalous effects in such material (*27*). Probably the best safeguard against this type of reaction is the regrouping of the sample with a series of antisera of both human and animal origin, one of which at least is not specific for either the A or B antigen. Other solutions have been suggested, mainly along the lines of substitution of a protein medium for the physiological saline in which the inhibition test is normally carried out. The use of sera of human origin for this purpose must always be regarded with suspicion, because of the occurrence of alcohol-soluble group-specific substances in the sera of all individuals, regardless of secretor status (*28*). It would be preferable, and probably of some value, to experiment with diluents of animal origin, provided that these could be shown to be devoid of substances similar to the ABO antigens.

Anti-H Agglutinins

In recent years studies on plant agglutinins (lectins) have revealed the existence of antibodies to the ABO antigens, including some specific for A_2. Probably the best known of these is the extract of *Ulex europaeus*, now widely used as an anti-H agglutinin. Anti-H agglutinin from the seeds of this and other plants has been used for typing of tissues, as has also the naturally occurring anti-H agglutinin of eel serum (*29*), bovine anti-H (6- described as anti-O) (*30*), and immune rabbit serum. The use of anti-H agglutinin was proposed by Mourant (*31*) for assistance in the diagnosis of group O. The opportunity presented, to demonstrate positively the presence of a third antigen H, is of considerable importance. It is not yet known whether the H antigen degenerates at a rate different from the rates for A or B antigens; in the absence of reactions for A and B antigens and in the presence of reactions for H, the sample may be presumed to be group O. The opportunity to add this information to that provided by the ABO group gives further scope for anthropological deductions.

Anthropological Applications

It has been said that many of the criteria for the identification of the dead can be forged, although it is

almost impossible to deceive the expert. No forgery can be undertaken with the blood groups, unless we accept the interference of bacteria as criminal action! The use of statistics on the ABO groups throws light on many anthropological problems. One of the most interesting, touched on by the Boyds, is the date of introduction of these groups into America by the successive waves of migrants. Candela's data on Aleut mummies (*32*) have been used by Laughlin (*33*) in discussing the origins and racial affinities of the present population of the islands. It is possible that further studies would show relative dates for the introduction of the different ABO groups into the American continent. Group O is predominant there today, notably in South America, where work on ancient mummies and skeletons could contribute to the solution of such problems as the origins and racial affinities of Inca and pre-Inca peoples. But North America shows areas of high incidence of group A—an incidence that increases as one moves northwards. When did this gene arrive, and where did it come from? Is it possible to demonstrate the absence of group B in old Indian populations, or will its presence suggest an Asian origin, as has been postulated for the Eskimo? It is equally possible that it could be demonstrated that groups A and B had been lost in New World populations of the present day. Many fascinating problems can be posed, on the origins and the migrations of peoples all over the world. As our techniques improve and our knowledge extends, we shall add many more. It is the function and the adventure of paleoserology to solve them (*34*).

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34. I wish to thank K. P. Oakley and A. E. Mourant for giving me the benefit of their comments on this article, and the Wellcome Trust for making my work possible.

Optics of Light Sources Moving in Refractive Media

Vavilov-Cherenkov radiation, though interesting, is but an experimental instance of a more general problem.

I. M. Frank

For a number of years the Vavilov-Cherenkov effect appeared as but a peculiar optical phenomenon difficult to observe. Light emission was induced by using radioactive preparations, and the glow was observed visually (*1*). The weakness of the glow seemed to preclude any application of the phenomenon in physics, and this was even more true in engineering.

Peculiarities of Radiation in a Medium

Since the theory of the Vavilov-Cherenkov effect appeared (*2–4*), the phenomenon could be regarded as an instance of superlight-velocity optics. This was a singular example in this field, which seemingly was isolated from any other known physical phenomena. It was evident that in principle other manifestations of superlight-velocity optics were also possible, but their observation appeared very complicated. For example, even the first calculations indicated that if the Vavilov-Cherenkov radiation were induced not by an electric charge but, say, by the magnetic moment of an electron, it should be so weak that its experimental detection would not be feasible (*5*). It was likewise evident that it would be difficult to create conditions for observation of atoms moving at superlight velocities (*6*).

Theoretical analysis of all these problems was for a number of years of interest chiefly from the viewpoint of principle.

Progress in nuclear physics and the improvement of experimental techniques in recent years has resulted in the fact that the Vavilov-Cherenkov effect has found numerous applications in the physics of high-energy particles. A connection between this phenomenon and many other problems has also been found, as, for example, the physics of plasma, astrophysics, the problem of radio wave generation, the problem of acceleration of particles, and so on.

A broader approach to the treatment

of the phenomena related to the Vavilov-Cherenkov effect has now become not only justified but essentially necessary.

The question naturally arises as to the peculiarities of a radiation which may be set up not only by an electric charge, but by any source of light, moving in a refractive medium (*7*). Such a general approach to the problem, involving, notably, the Vavilov-Cherenkov effect, is of interest now not only from the viewpoint of principle. It may be hoped that some phenomena of this range will become, in the immediate future, a subject of experimental study, too.

Since the discovery of the Vavilov-Cherenkov effect, our ideas of the mechanism of interaction between a rapidly moving particle and a medium have undergone a considerable change.

Formerly it appeared unquestionable that radiation arising during an electromagnetic interaction between high-energy particles and a medium is always some kind of bremsstrahlung. Most of the energy of such radiation is carried by high-energy photons. The optical properties of the medium should not be of significance for the emission and propagation of such photons. It was also assumed that the processes of ionization and excitation by fast particles might be regarded as a sum of independent interactions of such particles with individual atoms and molecules. This led to the deduction that generally for interaction between high-energy particles and a substance, macroscopic properties of the medium are likewise of no importance.

The discovery and interpretation of the Vavilov-Cherenkov effect, and then the connection between this phenomenon and ionization losses, found by Fermi (*8*), have led to a revision of this viewpoint. It has now become evident that the macroscopic properties of the medium play an important part in the processes of radiation of light by rapidly moving particles.

The ratio between the velocity of the emitter and that of light is a highly important factor, on which radiation depends. In a vacuum, the velocity of light is constant and always exceeds that of the emitter. It enters the formulas determining the radiation, as a universal constant. Radiation in a vacuum is therefore determined solely by the nature of the emitter and the law of its motion. The case is different in a refractive medium. The phase and group velocities of light differ from those in a vacuum. They depend on the properties of the medium and on the frequency of the light. In optically anisotropic media, they are a function of the direction of propagation and polarization of the waves. In media of limited dimensions, changes in the velocity of light during transition through the boundary of the media are also of importance. Hence, in a refractive medium, the ratio between the velocity of the emitter and that of wave propagation depends considerably on the velocity of light in a medium and on its changes. Unlike the ratio in a vacuum, the ratio may, notably, exceed unity. As a result, not only the properties of the radiation but sometimes even the radiation phenomenon itself depends on the peculiarities of light propagation in a medium. The Vavilov-Cherenkov effect is a case in point.

Radiation in a medium naturally also depends to a very great extent on the nature of the emitter. The theory makes it possible to foretell the properties of the Vavilov-Cherenkov radiation not only for a moving electric charge but also for other cases. For instance, similar to an electric charge, the Vavilov-Cherenkov radiation should have also been produced by a magnetic charge, had it been proved to exist (*9*).

Whereas the question of radiation of a magnetic charge should now, too, be considered as being only theoretically possible, the question of the Vavilov-Cherenkov effect for magnetic and electric dipoles and multipoles is quite real at present.

As a matter of fact, analysis of the radiation of a moving system of particles may prove necessary in resolving the numerous tasks related to processes in plasma and to problems of acceleration of particles. It is evident that a system of particles may, notably, be quasineutral, but it may possess an electric and, particularly, a magnetic moment due to moving ring currents.

Not only may a system of particles move as a whole, it may also have natural frequencies of oscillations. This is true to an even greater extent of such systems as a moving atom, ion, or atomic nucleus. An electron moving in a magnetic field may likewise possess natural frequency (Larmor frequency of revolution about the lines of a field). Therefore, apart from generalization of the theory of the Vavilov-Cherenkov effect, analysis of the general case of the radiation of systems possessing natural frequencies of oscillations is also required (*7*).

Such a general analysis also includes the Vavilov-Cherenkov effect. The latter corresponds to the limiting case when the natural frequency is zero.

The fact that the theory of radiation of a charge moving with a velocity exceeding that of light has not been revised in the past 20 years does not mean at all that the theory of this effect has been fully consummated. This can be seen from the following example. L. I. Mandelshtam was the first to point out that it is not necessary for a charge to move in a continuous medium in order to radiate during superlight velocity (*10*). The radiation remains the same if the charge moves along the axis of a hollow cylindrical channel inside the medium, provided the diameter of the channel is small in comparison with the length of the emitted wave. For practical purposes this is very important, since it makes it possible to obtain radiation in a medium under conditions when the emitter does not collide directly with the atoms of the medium, which may deform or destroy it. It seemed that this applies also to the radiation of a dipole in a medium.

As was recently shown, however, by V. L. Ginzburg and his associates, this question is not so simple as it appeared before (*11*). The properties of a medium directly adjacent to the dipole may play an important part, and the presence of a channel of any, even the smallest, diameter cannot, therefore, be ignored.

This important factor has called for a critical analysis of the formerly obtained data as well. Thus, two contradictory results were obtained by two different methods for the radiation of a magnetic dipole (*6, 9*). It may now be assumed that this was not due to the erroneousness of one of the methods used, but to the fact that the methods differed in taking into account the effect of the medium adjacent to the moving dipole. Possibly both results are correct, but they apply to different physical cases. The matter requires, however, further consideration.

The series of problems dealt with in this article, despite their diversity, comprises but the simplest case of radiation in a medium—namely, radiation during

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which the translational motion of the system may be regarded as uniform and rectilinear.

Transition Radiation

A typical example of radiation in a medium and, notably, during the uniform motion of an electric charge is provided by the so-called transition radiation. The assertion that there is no radiation during a rectilinear and uniform motion of an electric charge at a velocity smaller than the phase velocity of light is correct only under the condition that the velocity of light along the path of the particle remains unchanged. For example, if a uniformly moving charged particle crosses the boundary of two media with different indices of refraction, transition radiation appears. Radiation appears because the jump in the magnitude of the phase velocity of light at the boundary of two media is to some extent equivalent to the jump in the magnitude of the velocity of a particle. The equivalence to bremsstrahlung becomes complete in an extreme case, when the particle moves from a vacuum to a metal in which light is absorbed over a length smaller than the wavelength of the light. The intensity of the transition radiation is at its maximum in this case. In the optical range of the spectrum, the spectrum and magnitude of the radiated energy are then exactly identical to those of the radiation which would have been produced by an electric charge and a charge of the opposite sign moving toward it (its electric image in the metal) which stop instantaneously at the point of encounter.

The spectral density of energy of transition radiation at low velocities is proportional to the kinetic energy of the particle, and it rises in the region of relativistic velocities as the logarithm of the total energy. Like bremsstrahlung, it becomes sharply directed in this case. It has been suggested that transition radiation might be useful in determining the energy of ultrarelativistic particles. This is important because it is very difficult to use for this purpose the Vavilov-Cherenkov effect for ultrarelativistic particles. As is well known, the angle at which the Vavilov-Cherenkov radiation is directed and the intensity of the radiation attain in this case a practically constant value.

The use of transition radiation is, however, impeded by the fact that its intensity is very low. The probability of emission of a photon is of the order of the fine-structure constant—that is, of the order of a hundredth. If it is not possible to sum up transition radiation from many plates, observation of an individual particle by transition radiation may be carried out with but little efficiency. In this connection I should like to note the peculiarities of transition radiation at ultrarelativistic velocities. Unlike particles with a low velocity, transition radiation is almost the same during the incidence of such a particle from vacuum on a transparent dielectric as during the incidence on a metal. This is easy to understand by analogy with bremsstrahlung. Indeed, a change in the velocity of light is equivalent to a slight change in the velocity of the particle. But even a small change in the velocity of an ultrarelativistic particle means a great change in its energy—that is, a great deceleration of the particle. This peculiarity may permit us to sum up transition radiation from the surfaces of many parallel transparent plates in a vacuum.

The second peculiarity consists in the fact that at ultrarelativistic velocities, the equilibrium field entrained by the particle in a vacuum is formed along a considerable path length. Consequently, to prevent the intensity of radiation from being reduced, the vacuum layers between the plates should not be less than some preset magnitude. For instance, for the radiation of the visible light of a proton with energy of 10^{11} electron volts, this minimum distance is of the order of 1 millimeter, which is reasonable; but for a proton with energy of 10^{14} electron volts it rises to the unreasonable magnitude of 1 kilometer.

I have dwelt on the subject of transition radiation in order to emphasize the peculiarity of the optical phenomena for radiation sources moving in refractive media, which so greatly depends on the peculiarities of propagation of light in a substance.

It should be noted that although the theory of transition radiation was developed by Ginzburg and me (*12*) more than ten years ago and has since been analyzed in a number of works (as *13*, *14*), it has not yet been studied experimentally. The situation in this case is almost the same as in the case of the Vavilov-Cherenkov radiation before the papers of these workers were published. There is no doubt that transition radiation has also been observed on numerous occasions by various physicists, since the glow of the surfaces of electrodes under the impact of bombarding particles is well known. But even today the part played in this glow by luminescence, bremsstrahlung, and transition radiation has not been elucidated. The most reliable data on transition radiation have recently been obtained by Chudakov (*15*). Using the coincidence method, Chudakov observed photons emitted from the surface of a metal foil during the incidence on it of fast electrons from radiophosphorus. The intensity of radiation thus found proved to coincide with the estimated intensity for transition radiation, at least in order of magnitude (*16*).

It is also worth mentioning that transition radiation is practically always an intrinsic part of the Vavilov-Cherenkov radiation, due to the limited thickness of the radiator. As shown by V. E. Pafomov for a radiator of very small thickness, this factor should be taken into account (*17*).

Radiation Spectrum and Quantum Interpretation of the Phenomenon

The radiation of a charged particle uniformly moving at a velocity exceeding that of light may, as is well known, be fully described by the methods of classical electrodynamics. The quantum theory of this phenomenon was first developed by Ginzburg (*5*) and then by many other investigators (see, for example, *4*). Ginzburg has shown that the classical formula for the cosine of the angle at which radiation occurs is correct up to a very small correction of the order of magnitude of the ratio between the energy of the radiated photon and the total energy of the moving emitter. (Even for an electron the ratio is less than 10^{-5}.) If this slight quantum correction contained in the exact formula is disregarded, identical relations between the frequency of the radiated light and the direction of its emission are obtained by both the classical and the quantum methods. Let us write them down in a quantum form for a system possessing a natural frequency ω_0 (*7*, *18*), which is the frequency in the laboratory system of coordinates—that is,

$$\omega_0 = \omega'_0 (1 - \beta^2)^{1/2}$$

There is no need to assume in this case that ω_0 is the only natural frequency possessed by the system. It may be regarded as a component of a com-

plex spectrum of frequencies, and it should be sufficient to study the radiation related to this frequency.

If the momentum of the photon, which in a medium should be assumed to equal $n\hbar\omega/c$, is very small in comparison with that of the emitter, then the law of conservation of momentum during radiation may be expressed as follows:

$$(n\hbar\omega/c)\cos\theta = \Delta E/v \qquad (1)$$

where ΔE is the change in the kinetic energy of the emitter, and v is its velocity. From this ratio we obtain the magnitude of the change in the momentum of the system.

The change in kinetic energy is apparently determined by the energy of the radiated photon $\hbar\omega$ and the change in the internal energy of system $\hbar\omega_0$.

$$\Delta E = \hbar\omega \pm \hbar\omega_0 \qquad (2)$$

The term $\hbar\omega_0$ should be taken with a minus sign if, when emitting the photon, the system passes from a higher energy level to a lower one—that is, if the energy of the emitted photon is supplied, partly at least, from excitation energy. The plus sign should be used if the system becomes excited in the process of emission that is, if the kinetic energy is spent both on radiation and excitation.

By combining Eqs. 1 and 2, we obtain

$$(n\omega/c)\cos\theta = (\omega \pm \omega_0)/v \qquad (3)$$

Factor $\hbar$ has been canceled out, and the equation does not, indeed, contain anything of a specifically quantum nature. The same result is also obtained from classical wave analysis.

In Eq. 3 we can distinguish three cases.

1) Let us assume that

$$(nv/c)\cos\theta = 1 \qquad (4)$$

Then Eq. 3 is satisfied only if $\omega_0 = 0$. This is precisely a case of Vavilov-Cherenkov radiation, while Eq. 4 is a well-known condition determining the direction of emission of light for this radiation. The natural frequency $\omega_0 = 0$ required for bringing Eq. 4 into effect means that the moving system should contain a source of time-independent electromagnetic field (an electric charge, a constant dipole moment, and so on). Consequently, for the Vavilov-Cherenkov radiation to take place it is necessary that the constant component of the field should differ from zero. In this case, Eq. 4 yields the relation between angle θ and the radiated frequency, inasmuch as the index of refraction $n(\omega)$ is a function of frequency.

2) Suppose now that the left-hand member of Eq. 4 is less than unity. Then Eq. 3 may be satisfied only if ω_0 has a minus sign—that is,

$$\frac{n\omega}{c}\cos\theta = \frac{\omega - \omega_0}{v}; \quad \frac{nv}{c}\cos\theta < 1 \qquad (5)$$

This is nothing else but the Doppler condition for a source of light in a moving medium. It was obtained by Lorenz when he was studying the optics of moving media.

Equation 5 may evidently be expressed in the following ordinary way:

$$\omega = \frac{\omega_0}{1 - (nv/c)\cos\theta} \qquad (5a)$$

It determines the frequency when the component of the velocity along a ray, $v\cos\theta$, is less than the phase velocity of light c/n for frequency ω.

Equations 5 and 5a differ from the usual Doppler condition for a source of light moving in a vacuum only in that the velocity of light in a vacuum has been replaced by the phase velocity c/n. If v is small in comparison with the phase velocity of light, and if the dispersion of light is not great in the range of frequencies close to ω_0, this does not lead to anything fundamentally new. There is only a change in the absolute magnitude of the Doppler shift. It is obtained as if for light moving in a vacuum at a velocity equal to nv, or n times greater.

If the dispersion of light in the medium is great, important peculiarities arise. The presence of dispersion should not be ignored in any medium when the velocities of motion are comparable to the phase velocity of light. Indeed, with n constant, and for $\theta = 0$, the quantity $(nv/c)\cos\theta$ would tend toward unity with an increase in v, while ω, as can be seen from Eq. 5a, would tend toward infinity. At still greater velocities, the inequality sign in Eq. 5 would not be valid, and consequently there would be no solution. As a matter of fact, the refractive index of any medium becomes practically equal to unity at sufficiently large values of ω. Hence the Doppler frequency in this case is the same as it would have been in a vacuum—that is, it is certainly finite. In other words, at any velocity v and any value of θ, Eq. 5 will have a solution. Moreover, as is shown below, there may not be one but several solutions (*6, 7*) ("complex" Doppler effect).

3) The third case takes place when the left-hand member of Eq. 4 is greater than unity. Then a plus sign should appear before ω_0 in Eq. 3, and thus

$$\frac{n\omega}{c}\cos\theta = \frac{\omega + \omega_0}{v}; \quad \frac{nv}{c}\cos\theta > 1 \qquad (6)$$

This is a generalization of Doppler's formula for the case when the velocity of the emitter exceeds the phase velocity of light for a radiated frequency (*6, 18, 19*). It determines the "superlight" Doppler frequencies. Like the Vavilov-Cherenkov effect, the superlight Doppler frequencies appear when the velocity exceeds some threshold velocity. They are radiated simultaneously with ordinary frequencies, but only at sufficiently high velocities and within some range of acute angles.

It can be seen from the above quantum analysis that the plus sign at ω_0 in Eqs. 2 and 6, respectively, means excitation of the system. Hence radiation of superlight photons occurs not during the transition from the higher—that is, excited—state into the lower state, as in a general case, but quite the contrary, from the lower into the higher state, the energy being supplied from the kinetic energy of the translational motion of the system (*18*). Such a radiation, accompanied by excitation of the system, should take place spontaneously if the system is in the lower energy state. This is likewise possible as a spontaneous transition of the system from the higher energy state into the lower, accompanied by emission of photons with a frequency satisfying Eq. 5. As a matter of fact, the transition occurs in either case between the same energy states, and the question as to which of them takes place spontaneously is wholly determined by the initial state and the requirements of the conservation laws. In this case Eqs. 5 and 6 are, in equal degree, consequences of these laws.

The question regarding the Doppler effect in a refractive medium may also be considered within the framework of classical physics. From the viewpoint of classical physics, the results are interpreted as follows. Oscillations with natural frequency ω_0 bring about the appearance of radiation with frequencies which depend on the direction of propagation. It forms a spectrum of Doppler frequencies, which may be of two types. There is always a spectrum of radiation with frequencies satisfying Eq. 5, whose

reaction on the emitter causes its damping. Under certain conditions, another spectrum with frequencies satisfying Eq. 6 appears, in addition to the first. The reaction of radiation of these frequencies promotes the building up of oscillations. If damping prevails over building-up, oscillations will not arise by themselves in a system for which the classical formulas are correct, and if oscillations existed in the beginning, they will be attenuated.

In a quantum system the situation is fundamentally different. The processes of quantum radiation should be considered separately for spectra of both types. Therefore, if a process corresponding to Eq. 6 is possible, it is certain to take place—that is, the system will become excited owing to its own kinetic energy, will radiate light, and will pass in the usual way to the lower state. In principle, a two-photon mechanism is also possible, photons of both types being radiated simultaneously. Hence, as in the Vavilov-Cherenkov effect, a system possessing a natural frequency of oscillations will spend its kinetic energy on radiation at superlight velocity (*18, 20*).

This can be formulated in the following way. As is well known, motion at a velocity greater than that of light is impossible in a vacuum. It is possible in a medium, but nature does not lift its ban completely. Any system capable of interacting with radiation will slow down at a superlight velocity by radiating light.

Radiation Thresholds

It is evident from the above analysis that the radiation spectrum is determined by the velocity of motion of the system, v, its natural frequency, ω_0, and the phase velocity of light, c/n, in a medium in which the radiation is emitted. Both the Vavilov-Cherenkov effect and the Doppler superlight effect are possible, as can be seen from Eqs. 4 and 6, if $vn(\omega)/c > 1$. This obvious condition for the threshold of their appearance means that the velocity of motion should exceed the phase velocity of light.

This statement, correct for an isotropic medium, determines the threshold of emission of light of a given frequency ω for which the refraction index equals $n(\omega)$. As the refraction index depends on frequency, the threshold is different for another ω. This justifies raising the question in another way: Under what condition do the Vavilov-Cherenkov effect and Doppler superlight effect generally become possible in a given medium (*21*)?

During radiation in a medium there is yet another peculiarity which likewise appears under certain threshold conditions. It consists in the following. Equation 3 and, naturally, its sequels Eqs. 4, 5, and 6, are not linear with respect to ω. As a matter fact, they contain the refraction index $n(\omega)$, which is a function of the radiated frequency. As a result, not one but several values of ω, satisfying Eq. 3, are possible in some cases for given values of θ, v, and ω_0. This means that several components of different frequency may be radiated simultaneously in a given direction. The appearance of such additional frequencies—that is, of the so-called complex effects of radiation—is possible only under certain conditions. They may arise not only in the superlight Doppler effect and Vavilov-Cherenkov radiation but also in the ordinary Doppler effect subordinated to Eq. 5.

L. I. Mandelshtam was the first to draw attention to the fact that the condition under which the complex Doppler effect appeared (*6*) was related to the magnitude of the group velocity of light. The statement proved to be of a general nature (*7*).

If we consider radiation in the direction of motion, then in all the enumerated cases the condition for appearance of the radiation or of its new components is that the velocity of the emitter should equal the group velocity of light for a frequency which may radiate (that is, which satisfies condition 3). This threshold frequency should evidently satisfy Eqs. 4, 5, or 6, depending on the kind of radiation under consideration.

It is well known that in a refractive medium the transfer of radiation energy occurs not with the phase but precisely with the group velocity. Thus, it is not surprising that the group velocity of light is of importance for the processes of radiation in a medium.

The fact that the radiation threshold is connected precisely with the group velocity can be explained by some simple qualitative considerations. Let us assume that the conditions for appearance of the radiation have been fulfilled. Radiation arises and carries energy away from the emitter. Suppose, furthermore, that the velocity of motion changes and approaches the threshold velocity. When the threshold is attained, the radiation should disappear—that is, removal of energy from the emitter ceases. When the velocity of motion equals the group velocity of light, this will actually take place, since there occurs simply a transfer of energy together with the emitter.

The condition of appearance of the complex effect may be easily determined by analyzing the chart in Fig. 1. The curve in Fig. 1 represents dependence of the magnitude of wave vector

$$\kappa(\omega) = \omega n(\omega)/c$$

on the frequency for some imaginable medium. In addition to curve $\kappa(\omega)$,

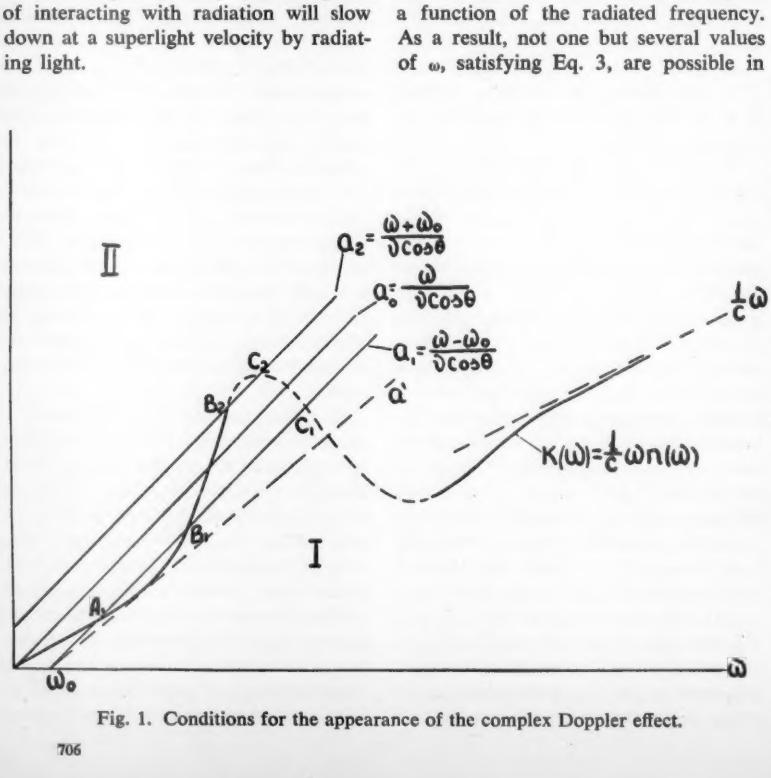

Fig. 1. Conditions for the appearance of the complex Doppler effect.

Fig. 1 contains three straight lines whose equations are

$$a_0 = \omega/v \cos\theta \quad (7)$$
$$a_1 = (\omega - \omega_0)/v \cos\theta \quad (8)$$
$$a_2 = (\omega + \omega_0)/v \cos\theta \quad (9)$$

The points where the straight lines cross the curve seem to determine at once the frequencies satisfying Eqs. 4, 5, and 6, respectively.

The tangent of the angle of incline of the straight lines a_0, a_1, a_2 to axis ω apparently equals $1/v \cos\theta$. Let us assume, in accordance with Fig. 1, that $\cos\theta > 0$—that is, $\theta < \pi/2$.

The nature of the intersections of the straight lines a with curve $\kappa(\omega)$ may differ. If we move along the straight line in the direction of increased ω, the straight line may go over at the point of intersection from the region underlying the curve (region I) into the region above the curve (region II). This takes place if the slope of the tangent to curve $\kappa(\omega)$—that is, $d\kappa/d\omega$—is less than $\gamma = 1/v \cos\theta$ (see, for example, point A_1 on the straight line a_1). On the contrary, if $d\kappa/d\omega > 1/v \cos\theta$, then there is a transfer from region II into region I at the point of intersection. Finally, $d\kappa/d\omega = 1/v \cos\theta$ takes place at the point of tangency.

As can be easily proved, the slope of the tangent to curve $\kappa(\omega)$ is equal to the reciprocal of the group velocity of light. Indeed, when there is no absorption, the group velocity W, as is well known, satisfies the relationship

$$\frac{1}{W} = \frac{d\kappa}{d\omega} = \frac{1}{c}\frac{d}{d\omega}(\omega n) = \frac{1}{c}\left(n + \omega\frac{dn}{d\omega}\right) \quad (10)$$

Hence, the group velocity of light for frequencies that can be radiated is related to the velocity of motion v and $\cos\theta$ by the relationships (*22*):

$(v \cos\theta)/W < 1$
transition from I into II (11)

$(v \cos\theta)/W > 1$
transition from II into I (12)

$(v \cos\theta)/W = 1$
tangency (13)

At a sufficiently high value of ω the quantity W becomes equal to c. Indeed, the refractive index tends toward unity, and hence curve $\kappa(\omega) = \omega n/c$ approaches a straight line with a slope of $1/c$.

The straight lines a rise more abruptly since $v < c$, and consequently $1/v \cos\theta > 1/c$. Hence, all three straight lines a are, at great ω, in region II.

This entails a number of consequences. First of all, it is evident that the straight line a_1 will necessarily cross curve $\kappa(\omega)$; that is, Eq. 5, as has already been noted, must always have a solution. As a matter of fact, the straight line a_1 passes through point $\omega = \omega_0$ lying on the abscissa, which means that the straight line must go over somewhere from region I into region II. Moreover, it means that at any rate a frequency is radiated for which inequality 11, corresponding to a transition from region I into region II, is applicable.

The straight lines a_0 and a_2, as might have been expected, do not always cross curve $\kappa(\omega)$. For them not to cross requires that their incline to the abscissa should be sufficiently small. This means that the velocity should be high and that angle θ should not be large.

At great ω both these straight lines also prove to be in region II. It follows from this that if there are crossings, then, at any rate, the last of them which determines the highest of the radiated frequencies corresponds to a transition from region I into region II. The result is then, again, that there is a frequency in the radiation for which inequality 11 is valid. For forward radiation, that is, $\theta = 0$, this means that there is a component for which $v < W$, and, consequently, that for at least a part of the radiation, energy is propagated at a higher velocity than that of the source of light (Eq. 5).

It also follows from the above discussion that if there is a frequency satisfying condition 12 (for instance, corresponding to point B_1 on the straight line a_1, the composition of the radiation will infallibly be complex, since there must be a frequency or frequencies satisfying condition 11. (In the general case the number of possible crossings for the straight line a_1 is always odd, and for the straight line a_2 always even.)

The boundary of the appearance of radiation or of new components of radiation is evidently represented by a case where the corresponding straight line a begins to touch curve $\kappa(\omega)$. This means the fulfillment of Eq. 13. With $\theta = 0$ we obtain, in agreement with the above, $v = W$ for the threshold frequency.

The dotted line in Fig. 1 corresponds to the threshold of appearance of the complex effect for the ordinary Doppler effect. As shown in the figure, the frequency begins to split when the slope of the straight line a_1 increases in comparison with that of the dotted line. This means that the complex Doppler effect arises in this case not when the velocity increases in comparison with the threshold velocity but, quite the contrary, when it decreases or when the angle

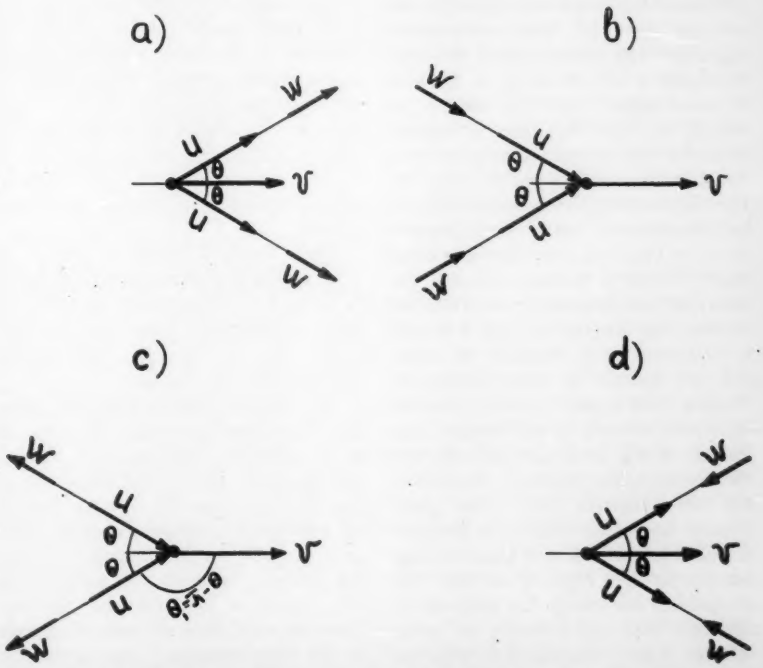

Fig. 2. Vavilov-Cherenkov effect in a medium with a positive group velocity: (*a*) radiation of energy, (*b*) absorption of energy; at negative group velocity: (*c*) radiation of energy, (*d*) absorption of energy.

becomes larger. [It is worth recalling that the tangent of the incline of the straight line a_1 equals $1/(v \cos \theta)$.] This is explained by the fact that the complex Doppler effect takes place here only within some range of velocities or angles, and the dotted line corresponds to the upper, and not the lower, threshold of the effect.

It has been assumed up till now that angle θ is acute—that is, that the product $v \cos \theta$ is positive. The statements made above regarding the complex Doppler effect may also be applied to the case of obtuse angles θ, but in this case negative group velocity will have to be taken into consideration. It appears that the threshold for the appearance of the complex Doppler effect, with $\theta > \pi/2$, is determined by Eq. 13. The quantity $\cos \theta$ is negative in this case; therefore Eq. 13 is valid only when the quantity W is less than zero. The import of negative group velocity for the Vavilov-Cherenkov effect was first investigated by Pafomov (*14, 17*) who pointed out that such a case should be real in anisotropic media (*23*). This is a very interesting case. We are accustomed to the idea that the Vavilov-Cherenkov radiation is directed forward at an acute angle. This is, however, correct only if the group velocity is positive. If it is negative, the picture is quite different.

Figure 2*a* shows schematically the ordinary case of Vavilov-Cherenkov radiation. The phase velocity for radiated light, $u = c/n$, forms in this case an acute angle θ with the direction of velocity v. The equation of electrodynamics also permits of the solution schematically represented in Fig. 2*b*. The direction of phase velocity—that is, the direction of wave propagation—forms in this case, too, the same acute angle θ with a velocity vector. The waves do not, however, come from the emitter, but towards it. The first case is interpreted as a radiation of waves, and the second, as their absorption. If there is no source of energy feeding the waves, flowing to the emitter, then the case of Fig. 2*b* is not realizable and the corresponding solution is rejected. But this is correct only if the group velocity is positive—that is, if its direction coincides with that of phase velocity (see vector W in Figs. 2*a* and 2*b*). The direction of the energy flux coincides in this case with the direction of phase velocity and, consequently, Fig. 2*a* really corresponds to the radiation of the waves, and Fig. 2*b*, to their absorption. In a medium with a negative group velocity, vector W is so directed as to meet vector u (the medium is considered optically isotropic, and hence vectors u and W may be only parallel or antiparallel). Therefore, with $W < 0$, Fig. 2*c* corresponds to radiation of energy, and Fig. 2*d*, to absorption of energy. Hence, if the group velocity is negative, the direction of the energy flux of the Vavilov-Cherenkov radiation forms an obtuse angle $\theta_1 = \pi - \theta$ with the direction of the velocity, and the motion of the waves is directed not from the particle but, quite the contrary, toward it (*24*). A similar analysis can also be made of an emitter with a natural frequency ω_0, moving in a medium with a negative group velocity (*7, 14*).

It can be seen from the above discussion that many substantial peculiarities of radiation in a refractive medium are actually related not only to the magnitude of the phase velocity of light but also to the group velocity of light. It may be expected that the role of the group velocity of light will reveal itself most distinctly in anisotropic media in which the directions u and W form some angle with one another.

Radiation in Optically Anisotropic Media

Radiation of a light source moving in a crystal should possess a number of features as compared with that in isotropic media. Interest in this range of problems has increased recently, in connection with studies of the processes in plasma (*25*). As to propagation of waves, a plasma placed in a magnetic field is similar to a uniaxial gyrotropic crystal.

The Vavilov-Cherenkov effect in crystals was first investigated theoretically by V. L. Ginzburg (*26*) and then by other investigators (see, for example, *4*). It has not, however, been studied experimentally to this day.

The equation determining the radiation frequency ω remains the same as in an isotropic medium—that is, ω is determined by Eq. 4. The magnitude of the index of refraction n in the case of an anisotropic medium depends, however, not only on the frequency of light but also on the angle and polarization. The result is that for the Vavilov-Cherenkov radiation the cone of normals to the wave surfaces is not circular in this case, as in an isotropic medium, but may have quite an odd shape. Thus, the direction of velocity does not necessarily coincide with the axis of the cone and in some cases may even lie beyond the cone (*17*).

Another peculiarity is related to polarization of the light. The Vavilov-Cherenkov radiation is always polarized. As a rule, polarization of light in this phenomenon does not attract attention, since it has not been used so far in present-day practical application of the radiation. However, from the viewpoint of the mechanism of the phenomenon, polarization is highly important. It is worth mentioning, for example, that the radiation of a magnetic charge, if it exists at all, could be distinguished at once from the radiation of an electric charge, since in this case the magnetic and electric vectors change places. The question of polarization of light is also of importance for the quite real case of radiation of dipoles and multipoles, though it has not yet been studied experimentally.

The role of polarization is manifested most distinctly in an anisotropic medium. First of all, one can obtain here, depending on the polarization of the radiated light, not one but two cones of wave normals corresponding to so-called ordinary and extraordinary rays in a uniaxial crystal. Moreover, the distribution of the radiation intensity is a complex function of the angles and is related to polarization of the light. The fulfillment of condition 4 does not suffice to bring about radiation, since the intensity of the waves of a given polarization may prove to equal zero. For example, if a particle moves in the direction of the axis of a uniaxial crystal, the cone of ordinary rays must disappear in the radiation (*4*).

The third peculiarity is related to the fact that in an anisotropic medium the direction of the ray—that is, the direction of a narrow beam of light—does not, generally speaking, coincide with the normal to the wave surface. There exist such directions of rays in a crystal, for which the normal to the wave surface forms some angle α with the ray (see Fig. 3).

The velocity at which the phase of the wave propagates in the direction of the ray, as can be seen from Fig. 3, is $1/\cos \alpha$ greater than the phase velocity; that is, $u' = u/\cos \alpha = c/n \cos \alpha$. We shall call u' the velocity of the waves along the ray. It should not be confused with the group velocity of light—that is, with the velocity of transfer of light energy which, naturally enough, is also directed along the ray. The group velocity equals velocity u' only

under the condition that there is no dispersion of light in the medium. Indeed, the velocity of the waves along the ray does not depend in this case on frequency, and hence the group of waves moves with the same velocity.

The velocity of the waves along the ray is important for radiation in anisotropic media. Let us consider in this connection the threshold velocity for the appearance of the Vavilov-Cherenkov effect. The assertion that the Vavilov-Cherenkov radiation for a light of frequency ω arises at a velocity greater than the phase velocity of light with the given frequency implies that the medium is isotropic. If this statement be considered applicable to anisotropic media (as will be seen below, it is not always applicable), it is necessary, at least, to indicate with which direction of the phase velocity the velocity of motion is to be compared.

Equation 4 $[(nv/c)\cos\theta = 1]$ is also valid for anisotropic media, and in this case $c/n = u$ is the phase velocity for the given direction of the normal to the wave, forming angle θ with vector $\mathbf{v}$. As is well known, when the velocity approaches threshold velocity in an isotropic medium, θ decreases to zero—that is, the cone of wave normals is compressed in the direction $\mathbf{v}$. In a crystal, the cone of wave normals is likewise compressed, in this case toward some axis which as a rule does not, however, coincide with $\mathbf{v}$. If this axis is represented by the direction of the velocity, the threshold $\theta = 0$, and then we obtain from Eq. 4 that $v = c/n$ where c/n is assumed for the direction $\mathbf{u} = (\mathbf{c/n})$ coinciding with $\mathbf{v}$. Hence, $\mathbf{v} = \mathbf{u}$. This relationship actually proves to be correct for boundary velocity in the usual cases of motion in a uniaxial crystal parallel or perpendicular to the optical axis. It has not, however, been stressed that it cannot always be applied.

It may be shown that the general condition for the appearance of the Vavilov-Cherenkov radiation of frequency ω should be formulated in the following way. The threshold velocity of the source of light should equal the velocity of waves along the ray in the direction of motion. In other words, the threshold velocity $\mathbf{v} = \mathbf{u}'$. For the threshold velocity, the direction of the ray coincides with $\mathbf{v}$ and not the normal to the wave, which forms an angle α with v. Hence, in the general case, the threshold value is $\theta = \alpha$.

In a special case, when the direction of the ray coincides with the wave normal in an anisotropic medium—that

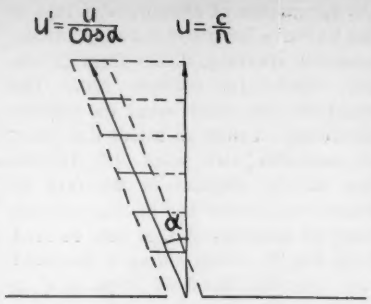

Fig. 3. Direction of a ray in crystals forms an angle α with the wave normal.

is, $\alpha = 0$, $\mathbf{u}' = \mathbf{u}$. Then we have $\mathbf{v} = \mathbf{u}$ for the threshold velocity. Finally, in an isotropic medium, where the phase velocity of light c/n is the same in all directions, it is possible to go over from vectors to scalar quantities, which means that $v = u$. Hence, the well-known statement that the velocity equal to the phase velocity of light is the threshold velocity has a limited field of application. It is a special case of a more general condition.

It is easy to explain this by using the Huygens principle for plotting the wave surface of radiation. This procedure is still generally used at present to describe the Vavilov-Cherenkov effect in an elementary way, and at the time it was one of the guiding ideas in the creation of the theory. This method can easily be applied to the case of an anisotropic medium.

The Huygens principle is frequently used in crystalloptics to explain the peculiarities of behavior of the so-called extraordinary ray during the refraction of light. The wave surface is found, by the Huygens principle, as an envelope of the waves emitted from separate points. Whereas, however, for an isotropic medium a sphere of radius $\zeta = (c/n)t$ is plotted around every point, where t is the time of movement of the waves, a crystal calls for a different approach. Of importance is the distance covered by the wave from a given point in the given direction of the ray. The distance equals the velocity of the waves along the ray, multiplied by time t—that is, $\mathbf{u}'t$. Therefore, the unknown quantity is represented by the envelope of the so-called surfaces of the rays plotted around every source of waves and determined by the equation $\vec{\zeta} = \mathbf{u}'t$.

Let us apply the Huygens principle to the case of Vavilov-Cherenkov radiation in a uniaxial crystal. The velocity of the ordinary and extraordinary rays is not the same here, and therefore, generally speaking, two cones of waves are obtained. In order not to encumber the drawing, they are shown separately in Figs. 4 and 5. We have to consider each point of the particle trajectory as a source of waves. In this case the wave phase is determined by the instant of passage of the particle through a given point. Let us assume that at moment $t = -t_3$ the emitter was at point A_3; at moment $t = -t_2$, at point A_2; at moment $t = -t_1$, at A_1; and finally, at the moment of observation $t = 0$, at point A_0.

For ordinary rays, the velocity of the waves along the ray, as in an isotropic medium, is equal to the phase velocity of light c/n and does not depend on the direction. The surfaces of the rays are simply spheres whose radii for points A_3, A_2, A_1, and A_0 are $(c/n)t_3$, $(c/n)t_2$, $(c/n)t_1$, and 0, respectively (see Fig. 4). The envelope of these spheres evidently represents a cone of circular cross section with the apex at A_0 (*27*). Its generatrices lying in the plane of the drawing are A_0B and A_0B'.

According to the Huygens principle, the directions of the rays are defined by the radius vectors drawn from some center of the waves to the point of tangency with the envelope. For example, in Fig. 4 (*left*) it is A_3B or A_3B', coinciding with the generatrices of the wave-normal cone for ordinary rays. Thus, the radiation cone is obtained for ordinary rays in the same way as in the Vavilov-Cherenkov effect in an isotropic medium. The substantial difference from an isotropic medium is related to the polarization of light and the distribution of intensity, depending on it. This was not taken into account in the construction.

From Fig. 4 it is not difficult to determine the magnitude of the threshold velocity. When the velocity diminishes, the distance between points A decrease. The threshold case arises when point A_0 occupies the position of A'_0 on the surface of the sphere. [This case is depicted separately in Fig. 4 (*right*).] At lower velocities, one of the spheres lies completely within the other and they do not have a common envelope. In the threshold case, they have only a common point of tangency A'_0. Thus, evidently, $(c/n)t_3 = v_0t_3$—that is, $v_0 = c/n$. The cone of wave normals is compressed in the direction of velocity v, and the wave cone transforms into a plane perpendicular to the axis of motion at point A'_0 [Fig. 4 (*right*)].

The Huygens principle can also be applied in a similar way to obtain a wave cone for the extraordinary rays (Fig. 5). The difference lies in the fact that surfaces of rays $\mathbf{u}'t_3$, $\mathbf{u}'t_2$, and $\mathbf{u}'t_1$, instead of spheres, are plotted around points A_3, A_2, and A_1. The cone enveloping the surfaces with an apex at A_0 is not circular in the case shown in Fig. Fig. 5 (*left*). The generatrices of this wave cone, A_0C and A_0C', lie in the plane of the drawing. The lines perpendicular to them, for instance A_3D and A_3D', determine the wave normals, and their length is proportional to the phase velocities. The vectors drawn from A_3 to the points of tangency A_3F and A_3F' indicate the corresponding directions of rays, which, as seen from Fig. 5 (*left*), do not coincide with the wave normals. It can also be seen from the drawing that the direction of an extraordinary ray for the Vavilov-Cherenkov radiation in a crystal may even constitute an obtuse angle with the direction of velocity [direction A_3F' in Fig. 5 (*left*)].

It is not difficult to determine the magnitude of the threshold velocity for the appearance of extraordinary rays in the Vavilov-Cherenkov radiation, which, generally speaking, differs from threshold velocity for ordinary rays. The threshold case occurs when the velocity diminishes to such an extent that point A_0 coincides with point A_0''. In this case all the surfaces of the rays lie within one another and have a common point of tangency A''_0. It can be seen from Fig. 5, which shows a threshold case, that the threshold value is $\mathbf{v} = \mathbf{v}_0 = \mathbf{u}'$. The wave cone then transforms into plane $A''_0\,D''$, and the wave normal forms an angle α with direction v. By tracing what happens to the cone of wave normals [its generatrices are A_3D and A_3D' in Fig. 5 (*left*)] during a decrease in velocity—that is, when point A_0 approaches A''_0—it is not difficult to prove that it is compressed not in direction v but in direction AD''. Hence, in a threshold case in Eq. 4, it may be assumed not that $\theta = 0$ but that $\theta = \alpha$. Then Eq. 4 produces $(nv/c)\cos\alpha = 1$—that is, actually, $v = c/(n\cos\alpha) = u'$.

It is worth recalling that with the aid of Figs. 4 and 5 we have determined the threshold of appearance of light of some given frequency ω. The velocity at which radiation generally appears is determined by a minimal magnitude of wave velocity of waves along the ray—namely, $u' = u'_{\min}$ in a given medium for a ray directed along motion. For frequency ω' for which $u' = u'_{\min}$, the velocity of the waves along the ray does not depend on frequency and is thus equal to the group velocity. Hence, we again come to the conclusion that the threshold is related to the group velocity.

The analysis of radiation of a system possessing a natural frequency of oscillations ω_0 may also be applied to the case of an optically anisotropic medium. The same peculiarities are manifested here as were referred to in connection with Vavilov-Cherenkov radiation. The connection between ω, θ, v, and ω_0 is determined, as before, by the same Eqs. 5 and 6 as in an isotropic medium, but now quantity n refers to the direction of a wave normal at an angle θ to the velocity.

The dependence of n on the direction

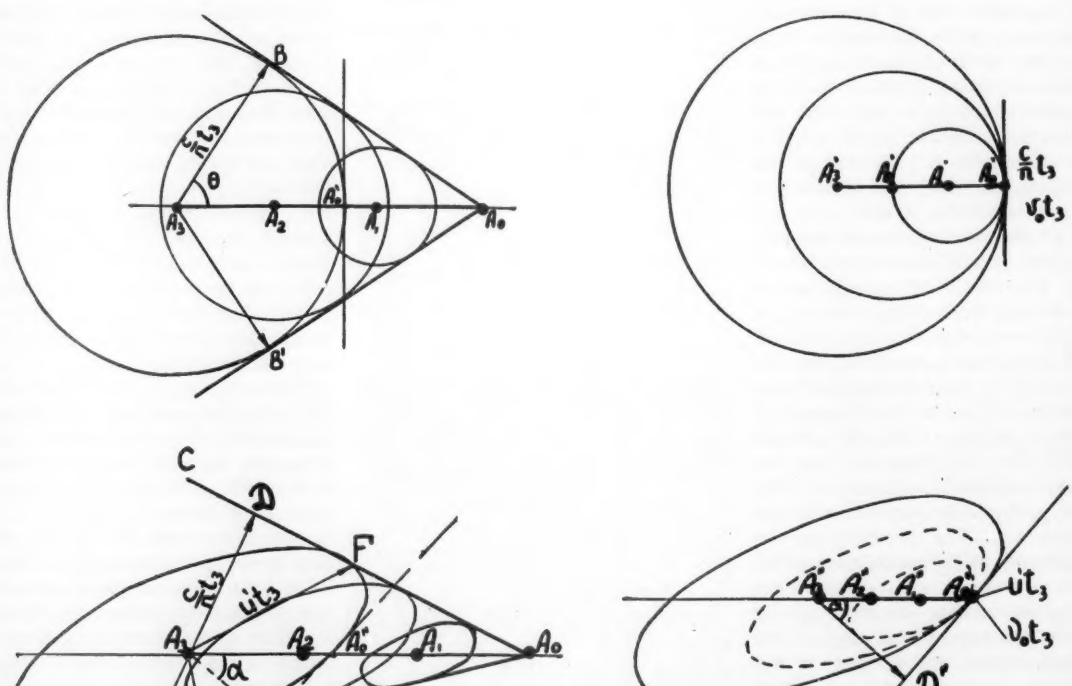

Fig. 4 (top). Wave cone (*left*) and the threshold case (*right*) for ordinary rays in a uniaxial crystal. Fig. 5 (bottom). Wave cone (*left*) and the threshold case (*right*) for extraordinary rays in a uniaxial crystal.

leads to the fact that the connection between θ and the frequency of radiation ω at preset natural frequency ω_0 and velocity v is not elementary. To find θ, use can be made of the graphic method suggested by V. E. Pafomov (*17*) for analyzing the Vavilov-Cherenkov effect in crystals, by applying it to the case of an arbitrary ω_0 (see Fig. 6). The figure shows a section of a surface of wave vectors $\vec{\kappa}(\omega) = \vec{\omega n/c}$ for the given ω in the case of extraordinary rays in a uniaxial crystal. The surface indicating dependence on the direction of vectors $\vec{\kappa}$ (they are oriented along the normal to the wave) differs from that of refraction indices only by a constant factor ω/c (we consider magnitude ω as prescribed). Thus, for a uniaxial crystal, the surface represents an ellipsoid of rotation. Let us assume that axis **v** is the direction of motion of the emitter. Let us plot on axis **v** segment OA of length b, which equals b_0, b_1, or b_2, depending on whether the analysis deals with the Vavilov-Cherenkov effect, the Doppler ordinary effect, or the Doppler superlight effect. Then

$$b_0 = \omega/v \qquad (14)$$

$$b_1 = (\omega - \omega_0)/v \qquad (15)$$

$$b_2 = (\omega + \omega_0)/v \qquad (16)$$

At point A, which is the end of b, we shall plot plane a perpendicular to axis v. Let us consider the curve where the plane crosses surface $\kappa(\omega)$ as a section of some cone with the apex at O. The generatrices of this cone, OC and OC', lie in the plane of the figure. The cone defines the magnitude and direction of vectors $\vec{\kappa}$ for light of frequency ω appearing in the case under consideration —that is, for the given kind of radiation with preset ω_0 and v.

Indeed, as can be seen from Fig. 6, $OA = b$ is a projection of vector OC or OC'—that is, of vector $\kappa = \omega n(\omega_1\theta)/c$. Hence,

$$\frac{\omega n(\omega, \theta)}{c} \cos\theta = b \qquad (17)$$

By substituting the values of b from Eqs. 14, 15, or 16, we obtain identical Eqs. 4, 5, or 6.

It can be seen from Fig. 6 that not only may the cone of wave normals be actually asymmetric but, as has already been mentioned, axis v may even lie outside the cone.

Plane a does not always cross the surface of $\kappa(\omega)$. This corresponds to the evident fact that not every frequency is radiated for given v and ω_0. If $b = b' = OA'$ (see Fig. 6), the plane touches the surface and, consequently, $b' = OA'$ is a boundary for the appearance of the given frequency ω in the spectrum. Vector $\vec{\kappa}$—that is, the wave normal, coincides in this case with OB. It can be easily proved that it forms angle α with the direction of velocity, the direction of the ray coinciding with that of motion. If, in accordance with this, angle $\theta = \alpha$ is inserted in Eq. 3, we obtain the following general condition for velocity v_0 required for the appearance of frequency ω:

$$\frac{\omega}{u'} = \frac{\omega \pm \omega_0}{v_0} \qquad (18)$$

where u' is the velocity of the waves along axis v (positive or negative—that is directed along v or opposite it). In a special case of the Vavilov-Cherenkov radiation, $\omega_0 = 0$.

Radiation of a system possessing a natural frequency of oscillations and moving in an optically anisotropic medium was first studied by K. A. Barsukov and A. A. Kolomensky (*28*). They elucidated a number of peculiarities of radiation related to the presence of ordinary and extraordinary rays and the significant role of wave polarization.

It is highly interesting that this seemingly more complex case appears to present even now some interest from an experimental point of view. Barsukov and Kolomensky made a special study of radiation of radio waves in the ionosphere, which behaves like an optically anisotropic medium under the action of the earth's magnetic field. It is important that this medium possesses strong dispersion at some range of frequencies and that the complex Doppler effect is possible in it. Kolomensky and Barsukov have pointed out that this phenomenon may take place in the case of radio waves of appropriate frequency, transmitted by an artificial earth satellite moving in the ionosphere. They found that the Doppler shift of frequency of the order of 10 to 100 cycles per second should be accompanied in this case by splitting of the radiation frequency into components of several hundredths of a cycle per second apart. Apparently, with a well-stabilized frequency of the transmitter, such splitting could be detected.

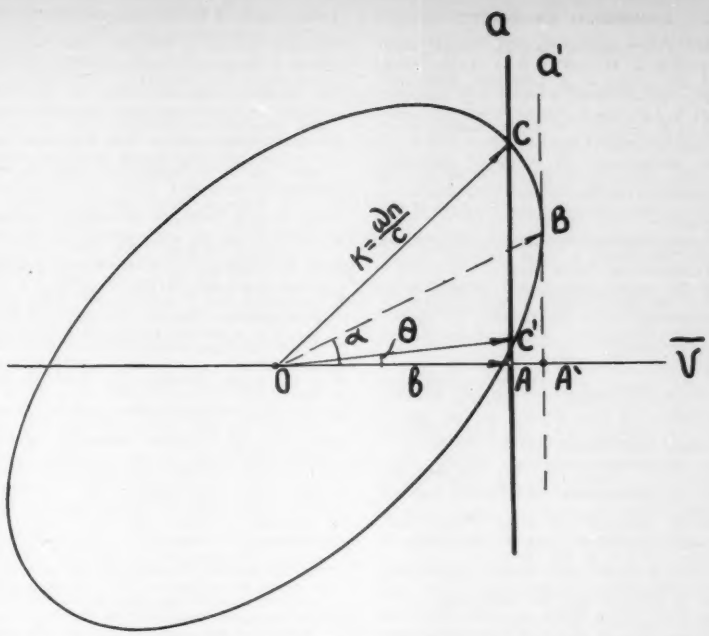

Fig. 6. Graphic plotting of a cone of wave vectors for radiation in crystals.

Conclusion

I have aimed to prove that there is a wide range of problems related to the radiation of sources of light, moving in refractive media. Radiation of an electric charge moving at superlight velocity in an isotropic medium—that is, the experimentally investigated case of the Vavilov-Cherenkov effect—is, in essence, but a special, though a highly interesting, instance in this realm of phenomena.

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13. G. M. Garibyan, *Zhur. Eksptl'. i Teoret. Fiz.* **33**, 1403 (1957).
14. V. E. Pafomov, *ibid.* **37**, 1853 (1959).
15. A. E. Chudakov, unpublished.
16. In the book by Jelley [*Cerenkov Radiation and Its Applications* (Pergamon, New York and London, 1958)], with which I had the opportunity of becoming acquainted after this article had been written, there is mention of the fact that in 1958 the author, together with Elliot and Goldsmith, observed a radiation emitted by 1.5-Mev protons incident on a polished aluminum target. On the basis of the data on the intensity and polarization, the investigators concluded that the glow was transition radiation. This observation has now been published as an article [P. Goldsmith and J. V. Jelley, *Phil. Mag.* **4**, 836 (1959)].
17. V. E. Pafomov, thesis, Physical Institute of the U.S.S.R. Academy of Sciences, Moscow (1957); *Zhur. Eksptl'. i Teoret. Fiz.* **32**, 366 (1957); *ibid.* **37**, 1853 (1959).
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19. Apparently Eq. 6 may be put down in a form similar to Eq. 5a. The difference consists only in that the sign in the denominator of the right-hand member of Eq. 5 should be changed.
20. I. M. Frank, *Usepekhi Fiz. Nauk* **30**, 149 (1946).
21. For the Vavilov-Cherenkov radiation in an isotropic medium, this point regarding the threshold is elementary, since the latter is determined simply by the maximum value assumed by the refraction index in the given medium. Of importance for further consideration is the fact that for a frequency corresponding to n_{max}, the phase and group velocities are equal (see Eq. 10), it being evident for n_{max} that $dn/dw = 0$. Hence, the fact that the threshold velocity of motion is equal to the phase velocity means that it is also equal to the group velocity of light.
22. The magnitude determined by Eq. 10 has the meaning of the group velocity of light only when there is no strong absorption—that is, in those regions of the spectrum for which the medium is transparent. The part of the curve $\kappa(\omega)$ corresponding to the region of anomalous dispersion, in which there is unquestionable dispersion, is shown in Fig. 1 by a dotted line. The peculiarities of radiation for frequencies getting into this region call for special consideration.
23. This is related to the fact that in an anisotropic medium the direction of the group velocity does not coincide with the direction of the phase velocity. This question is treated in the next section.
24. The analysis given in Fig. 2 is similar in many ways to the example given in L. I. Mandelshtam's lectures on the refraction of light by a medium with a negative group velocity [L. I. Mandelshtam, *Collected Works*, vol. 5, p. 463].
25. Some of the problems connected with plasma were dealt with in I. E. Tamm's Nobel lecture [*Science* **131**, 206 (1960)].
26. V. L. Ginzburg, *Zhur. Eksptl'. i Teoret. Fiz.* **10**, 608 (1940); *J. Phys. U.S.S.R.* **3**, 101 (1940).
27. Strictly speaking, such an analysis presupposes that there is a superposition of monochromatic waves. Each point of the trajectory should, therefore, be regarded as a source of such waves emitted for an infinitely long time. Actually, it is only the summation of waves of various frequency that produces a light impulse when the particle passes through a given point. Hence, there exists, of course, not one but an unlimited multitude of wave surfaces for a given frequency. The one that is generally plotted is singled out only by its passage through the instantaneous position of the particle (which we shall term the wave cone).
28. K. A. Barsukov and A. A. Kolomensky, *Zhur. Tekh. Fiz.* **29**, 954 (1959).

Significance of Carbon-14 Dates for Rancho La Brea

Tests analyzed in the light of early field notes emphasize the complexity of dating the several traps.

Hildegarde Howard

Carbon-14 datings are at last available on well-documented material from the Rancho La Brea fossil deposits of Los Angeles, California. These important deposits, first scientifically investigated in 1906, yielded tens of thousands of bones of extinct animals, as well as remains of insects and plants, and afforded a remarkable representation of the Pleistocene life of the Los Angeles Basin area. Although there has never been any doubt that these deposits were accumulated in Pleistocene time, there has been some change in thinking regarding the part of the Pleistocene represented (*1*) and its equivalent in terms of calendar years. Several years back, when I had occasion to conduct school groups through the exhibit of Rancho La Brea fossils at the Los Angeles County Museum, the expression "approximately 50,000 years old" was used in referring to the fossils. It has for some time been agreed that, geologically speaking, the deposits are of late Pleistocene age (*2*). Carbon-14 dating has revealed that some "late Pleistocene" glacial deposits are only 11,000 to 12,000 years old (*3*). Cave deposits containing remains of ground sloths identical with those found at Rancho La Brea have been given an age of 10,000 to 11,000 years (*4*). It has become a matter of considerable significance, therefore, to procure radiocarbon datings for the most prolific of all late Pleistocene deposits—Rancho La Brea.

In 1949, tests were made at California Institute of Technology by David L. Douglas (then a research fellow in chemistry) in the course of experimentation with the use of ionization chambers for measurement of low-level carbon-14. As Douglas did not consider his method to be perfected, and the pit source of the wood tested was unknown, his results were not noted in paleontological literature; they were, however, later recorded by Douglas (*5*) in an article explaining his method.

Tests have now been made on documented material, and by two laboratories: the Geochronometric Laboratory of Yale University, directed by Edward S. Deevey, and the Radiocarbon Laboratory developed by Hans E. Suess at the Scripps Institution of Oceanography of the University of California, La Jolla. Both laboratories tested sections from

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the same tree specimen from the Los Angeles County Museum excavation known as pit 3, with results as nearly identical as could be expected, even from separate tests at a single laboratory. The Scripps laboratory then tested a section of a wooden artifact taken from the large excavation known as pit 61–67.

The date for the tree from pit 3 was estimated to be about 14,500 years B.P. (before the present); the date for the artifact from pit 61-67 about 4450 B.P. Douglas's experiments gave a date for the undocumented wood of about 16,-350 ± 2000 years. In order that the significance of these datings may be understood, certain details connected with the excavations should be explained. The following information was largely obtained by careful study of the day-by-day field notes kept by L. E. Wyman, who was in charge of the Los Angeles County Museum excavations of 1913–15.

Early Excavations

The area in which the Rancho La Brea deposits occur comprises approximately 23 acres located on busy Wilshire Boulevard in Los Angeles. It is developed today as a scientific monument known as Hancock Park. The most extensive excavations for fossils were made by the Los Angeles County Museum in 1913–15. In connection with these excavations, 96 "pit numbers" were recorded. The majority of these numbers apply to mere test holes that yielded no fossils. Some of the other excavations, although separately numbered, were in reality made in groups around one spot. For example, eight test holes were dug in one area at the east end of the park where bones were found in profusion but in a very poor state of preservation; it was hoped that one test hole would strike a spot where preservation was good. Another group of four holes centered around a previous, rich, University of California site. The total number of separate bone-bearing "pits" represented by the museum's early excavations is actually only about 24; of these, six showed comparatively recent activity. Pits 3 and 61–67 were among the ten best fossiliferous deposits excavated by the museum.

No bones were recovered from open, liquid tar lakes. All but one of the excavations were made in solid ground (*6*). Bones were entombed in a matrix of tar-soaked sand and were usually not encountered above a depth of 2 to 4 feet. A capping of hardened asphaltum was usually found above this level, and the presence of such hard material on the surface often suggested the spot for the test hole. In some instances, small recent vents of liquid tar occurred in or beside the capping. The method of formation of the tar deposits and the part played by the activity of oil and gas in mixing the entombed materials has been described by Stock (*7*). Because of this activity, stratification as usually understood was nonexistent. Nevertheless, a grid system of 3-foot squares was worked out for the excavations, and grid and depth data were recorded for nearly all specimens. These records serve to provide general information regarding deposition and to suggest areas of irregular activity. They should not, however, be accorded the same degree of significance as data concerning true stratification.

Pit 3

Pit 3 was excavated by the museum from July 1913 through August 1914. It was one of the simpler deposits, fairly symmetrical in shape, possibly having accumulated in an old gully. It was approximately 15 feet in diameter at its upper levels, sloping to dimensions of only 2½ by 3½ feet at its maximum depth of 27 feet. On one sloping bank, a tree 8 feet tall was found upright, rooted in the clay that lay beneath the asphalt. The tip of the largest branch was first encountered at a depth of 4 feet. As the branch was uncovered by excavation, its connection with the main trunk was revealed. Both branch and trunk had a diameter of approximately 10 inches. Bones of the typical Pleistocene La Brea fauna were packed solidly around the branch and the trunk. The following quotation is from the field notes of 15 December 1913, the date on which the tree was removed from the pit: "Tree was rooted in a stiff clay, at 12 feet. Many roots, some of them large ones, penetrated the adjacent wall almost horizontally, others projected into a mass of clayey matrix, well-boned. Directly underneath the trunk the earth was loose and bones lacking. The whole aspect of things indicated that the tree had grown on the bank of a gully, or possibly at the edge of a bone deposit that had been completely covered with a heavy deposit of clay; and when the tree was well grown it was submerged by a vent breaking through underneath its branches." The wood of this tree has been identified as cypress.

The samples of the tree that were tested at the Yale laboratory were from the trunk and were accompanied by the following notes: "1. (Yale no. Y-354) 2-inch core bored in center of trunk, 33 inches from bottom of tree. Outside of wood penetrated by tar for approximately 1/16 inch; solid wood for 3½ to 4 inches; centermost part of core rotted, tar-soaked wood (center of tree apparently rotted, or tunneled by insects). 2. (Yale no. Y-355) 2-inch core bored 11½ inches above sample no. 1; details as in sample no. 1." The unrotted wood from each sample was used for testing; part of each sample was washed in xylol to remove the tar. The results were as follows (*8*): Samples from which tar was not removed, No. 1, 14,500 ± 210 years; No. 2, 14,110 ± 420 years. Samples from which tar was removed, No. 1, 15,390 ± 230 years; No. 2, 13,890 ± 280 years.

A section from the root of the same tree was sent to the La Jolla Laboratory, where it was tested with the technical assistance of George S. Bien and Paula Sandoval. The tar was extracted from this entire sample. The date obtained for the wood (sample No. LJ 55) was 14,400 ± 300; the extracted tar (sample No. LJ 89) tested essentially "dead"—that is, older than 28,000 years.

The dating of the tree from pit 3 undoubtedly could apply as well to the fossil bones of the extinct animals, such as ground sloth, horse, lion, mastodon, wolf, and saber-toothed cat, found to a depth of approximately 12 feet around the tree. It is possible, however, that earlier dates might apply to the bones found at the 18- to 27-foot levels. The presence of oxidized asphaltum and clay at the 15-foot level suggests a period of quiescence between the entrapment of the animals represented in the lower beds and those represented in the upper.

Pit 61–67

The museum's excavations of pits 61 and 67 were carried on concurrently, in the fall of 1914 through the spring of 1915. Both were started at the edge of an old artificial pond whose bed was then dry. Fossiliferous matrix was found under the pond bottom from a depth of about 6 feet below the surrounding surface to as much as 20 feet in some places. About midway through the

period of excavation it was observed that the two "pits" would join. The one to the west (started as pit 61) seemed to be a series of connected pockets, varying in cubic contents from 1 to 10 yards, connecting in turn (to the east) with a fairly continuous deposit some 15 feet in diameter which formed the major portion of the excavation originally called pit 67. Adjacent to and southeast of this major section of pit 67, the matrix was fossiliferous but broken by blocks of hardened asphalt that may, according to the field notes, have caved in from the banks in past times. At least 13 of the approximately 17 artifacts recovered from pit 61–67, and a great variety of shells, were found in a strip about 30 feet long by 3 to 6 feet wide, at depths of 11 to 18 feet, in this latter portion of pit 67 and its extension into pit 61. In recording the occurrence of the artifacts and shells, the field notes include the following comment under date of 26 April 1915: "There is in this a suggestion that an Indian camp was once located very close to this spot."

The artifacts are listed and discussed by Woodward (*9*). He found that the bulk of them correspond to artifacts known from Indian sites in southern California dating into the historical period. Four of them (all wooden), however, suggested an earlier culture, not previously recognized in southern California. These consist of a bunt foreshaft for an atlatl dart and three atlatl dart foreshafts. It was a section of one of the latter that was tested at the La Jolla Laboratory as sample No. LJ 121 and dated 4450 ± 200 years B.P.

Although scattered fossils were found near the artifacts, the contemporaneity of artifacts and fossils has always been questioned. In the first place, the whole south portion of the excavation was subject to such frequent crumbling and caving-in that one is inclined to question the validity of grid and depth notations for materials from this area. Furthermore, the irregularity of the matrix in this southeast portion and the occurrence of numerous pockets throughout the entire pit 61–67 deposit suggest that this area was extremely unstable over a long period of time and that there was probably considerable intermittent activity.

The appearance of new surface vents of tar is, even today, characteristic of the entire Hancock Park area. These vents represent chimneys formed by gas pressure from subterranean petroleum deposits. As they enlarge, they can become channels for conveying surface materials downward as well as for bringing tar upward. In some of the excavated deposits, "chimney" accumulations could be detected from the character of the matrix. It is, therefore, possible that vents occurred beside or through the ancient pit 61–67 deposit at a somewhat later time. The presence of large chunks of hard material intermingled with softer matrix in the southeast section suggests, further, that a fracture of some extent may have existed, causing the edges of the banks to crumble and fall as they were undermined by fresh tar or weakened by heavy rains. These observations, together with the comparatively recent date now recorded for one of the artifacts, substantiate our previous contention that the artifacts and fossils in pit 61–67 were not contemporaneous. Obviously the artifacts were not of Pleistocene age; the condition of the pit seems adequately to explain their association with fossil bones without assuming that the animals represented existed up to 4500 years ago.

From this brief discussion of two of the Rancho La Brea deposits, which have been sampled for carbon-14 dating, it will be obvious that age determination for the complete La Brea section is far from complete. It is quite possible that other samples from greater depth in pit 3, and samples of nonhuman origin in pit 61–67, will yield dates different from those yielded by the samples already tested. It is also of particular importance to obtain knowledge of the relative ages of the several other active Pleistocene pits. Wood from three of the most important of these is on deposit at the Scripps laboratory, and results are eagerly anticipated (*10*).

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2. C. Stock, *ibid., No. 13* (1949), p. 17, Fig. 5.
3. W. F. Libby, *Radiocarbon Dating* (Univ. of Chicago Press, Chicago, Ill., 1952), p. 88 (dating of wood and peat samples taken under glacial drift in Wisconsin).
4. ———, *ibid.*, p. 85 (dating of samples from Gypsum Cave, Nevada).
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6. One test was made in the center of the large tar and water lake on Wilshire Blvd., but the lake was drained first, and the hole was dug in bottom sediments. The fossils obtained were in a poor state of preservation.
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10. I wish to thank Edward S. Deevey and Hans E. Suess and their associates for aiding the Los Angeles County Museum in these important tests. I am also very grateful to Carl L. Hubbs of the Scripps Institution of Oceanography, through whom the arrangements were made for the tests at the La Jolla Laboratory.

Edward Chace Tolman: A Life of Scientific and Social Purpose

The era of the grand system-builders of American psychology draws to a close with the death of Edward Chace Tolman in Berkeley, California, on 19 November 1959.

Edward Tolman was born in Newton, Massachusetts, in 1886. He graduated from the Massachusetts Institute of Technology in 1911 with a B.S. in electrochemistry. Pursuing his combined interests in science and the philosophy of human conduct, he entered into graduate study in the joint department of philosophy and psychology at Harvard. After receiving his Ph.D. in 1915 and after a brief period of teaching at Northwestern University, Tolman came in 1918 to the University of California in Berkeley, where he remained for the rest of his career. It was here that he began the experimental and theoretical work that was to continue for four decades. It is fitting that his pioneering work started when he moved West. For the characteristics of the West that he came to love—its open expansiveness, its free and stimulating spirit—also became the characteristics of his system-building.

He built on a grand scale, and the stimulating conceptions of his system, ceaselessly changing and growing over the years, have had a profound influence upon the science of psychology and upon the generations of psychologists who studied with him.

To understand Tolman's systematic contributions it is necessary to understand the state of psychology when he entered the field. There was a ferment of ideas, new "schools" of competing theory were in process of growth, the "mentalism" of traditional psychology with its insistence on the methods of introspection was under attack from several different directions, most notably by Watson's behaviorism.

The behaviorists' attempt to make the study of psychological processes into an objective science appealed deeply to Tolman. He plunged into active research on the learning behavior of the rat, but he quickly came to reject the narrow behavioristic conceptions of stimulus and response. He also objected to Watson's notion that stimulus-response connections come into being through sheer frequency of conditioning and to Thorndike's hypothesis that stimulus-response connections are explicable in terms of accidental coupling of action and "reward" (Thorndike's "law of effect").

Tolman saw that these conceptions omitted the essential core of behavior—its purposiveness. The criteria of purposiveness he took to be the persistence of behavior toward a goal and its docility (teachability) with respect to goal achievement. And it was these characteristics that he insisted on putting back into a "purposeless" behavioristic model. He sought to do this in a manner which was scientifically sound and philosophically sophisticated. What he did, in effect, was to enlarge the scope, redefine the units of analysis, and alter the experimental techniques of behaviorism. He rejected the single, elementary "muscle-twitch" (behaviorism's original unit of analysis) as an improper unit and proposed instead a larger unit of behavior in which its essential purposive nature was preserved. Stimuli he conceived of in terms of environmental objects rather than as simple sensory impressions; responses he conceived of as adaptive rearrangements between organism and environment. He introduced the term *molar* behavior to characterize these larger and more functional units, as contrasted with the narrower *molecular* behavior of the muscle-twitch.

Edward Chace Tolman

Tolman's great achievement was that he was able to do all this without in any sense regressing to the earlier "subjectivism" of psychology. What he sought were *objective* measures of purpose—that is, those dependent upon the immediate observables of behavior. Unacquainted with Bridgman's contemporary writing on operational definition in science, Tolman proceeded independently to show the value of such objective definitions in dealing with complex psychological phenomena.

This is clearly shown in his treatment of cognition. Above all else Tolman insisted on a model of an organism that thinks and adapts as it learns. He endowed the rat, no less than man, with "expectations," "hypotheses," "means-end-readinesses." But he firmly insisted that these (whether applied to rat or man) be objectively defined and objectively measured. Thus he sought, and believed that he found in his challenging "latent-learning" studies, experimental evidence that the rat in learning to run a maze is learning "what leads to what" (a "cognitive map" of the maze) and not merely acquiring a fixed set of stimulus-response "connections."

The culmination of those early years of Tolman's experimental and theoretical work came in 1932 with the publication of his monumental book, *Purposive Behavior in Animals and Men*—a book which has been described as marking behaviorism's coming of age. This book represented his first major attempt at a comprehensive system of psychology. It was unprecedented in its scope, its wealth of experimental data, and its sheer originality. Here for the first time in a single system are put forth Tolman's views on molar behavior and its purposiveness, on the cognitive nature of learning, on the multidetermination of all behavior. A scheme is offered to encompass the lines of interaction among *all* of the many types of variables determinative of animal behavior. And the concepts are extended, with the greatest of tentativeness and sensitivity, to include unique aspects of human behavior.

But because Tolman was an experimentalist as well as a theoretician, he could not write *finis* to any theoretical effort as long as new experiments were being done in psychological laboratories. In the years after 1932 he continuously revised and extended this first systematic structure. To a degree unmatched among the great systematists he open-mindedly incorporated and transmuted contributions from the most diverse psychological sources: behaviorism, functionalism, Gestalt psychology, psychoanalysis. McDougall, Watson, Thorndike, Lewin, Köhler, Brunswik, Freud—the ideas and data of all these men (not always in forms they would recognize) find their places in Tolman's systematizing. Above all else Tolman was impressed with the complexity of behavior and therefore refused to shut his eyes to any reliable data—whether from the clinic, the field investigation, or the laboratory experiment.

The flow of Tolman's theoretical papers has reflected this ceaseless innovation and growth in his thinking. A major theoretical step forward came in his introduction of the concept of intervening variables. In seeking to analyze the complex relationships between stimuli and responses he recognized the indispensability of inferring "inner" processes mediating between stimulus and response. His aim was to deal with such intervening variables with objective rigor, and this he attempted to do by first separately determining the functional relationships between the independent variables (stimulus conditions) and the intervening variables (needs, cognitions, and so on) and then, secondly, determining the relationships between the intervening variables and the dependent variable (behavior). In this way he sought to break down the complex psychological analysis into manageable experimental steps.

The extraordinary professional esteem in which Tolman was held is shown by an unending flow of scientific honors bestowed on him. He was elected president of the American Psychological Association and three of

its divisions. He was vice president of the AAAS. He was co-president of the International Congress of Psychology. He was elected to the National Academy of Sciences, the Society of Experimental Psychologists, and the American Philosophical Society, of which he was also Penrose lecturer. He received many awards, including the Kurt Lewin Memorial Award and the Distinguished Scientific Contribution Award of the American Psychological Association. A number of honorary degrees were bestowed on him.

But these honors cannot convey a proper sense of the affectionate place Tolman occupied in the minds and hearts of his students and colleagues and of psychologists everywhere. He was a rare teacher, gentle and humane, capable of instilling permanent scientific enthusiasms in his students. Yet the enduring imprint of his ideas on his students made them not into disciples (this would have been the antithesis of all that Tolman stood for as a teacher) but into independent thinkers, who spread into fields of psychology far removed from the animal laboratory. He was generous of aid and faithfully supportive in his relations with his students and colleagues. His wit, warmth, and wisdom in departmental affairs helped, over the years, to build the department at Berkeley into one of the world's foremost, a reputation inseparable from the name of Edward Tolman. No description of the growth of the department can, however, be complete without reference to his wife, Kathleen Drew Tolman, whose grace and charm contributed so much to the camaraderie of the department.

Tolman the respected scientist, Tolman the beloved teacher, and Tolman the citizen were one and the same. As one of his colleagues at the university has put it, "No man was ever less divisible." His steady faith in the scientific method led him to regard all major problems of human behavior as properly susceptible to rational study by psychological means. Thus, his life-long abhorrence of war led him as a scientist to seek to contribute something to our understanding of the psychological sources of warlike behavior. His book *Drives Toward War* (1942) was the significant result.

His firm belief in the responsibility of the scientist to participate in the affairs of the human community is manifested in his long record of dedicated liberalism in the service of civil rights and individual justice. He served for many years on the national board of the American Civil Liberties Union. Most widely known to those in academic life was his effective leadership in the loyalty oath controversy at the University of California in 1950–52. Tolman never wavered in this fight for academic freedom, and the partial victory won at Berkeley benefited the cause of academic freedom everywhere. For, as the Washington *Post* pointed out in its editorial published on his death, "The fight led by Dr. Tolman challenged and helped to arrest a dangerous trend toward forcing a stultifying conformity on teachers." Despite his difficult role Tolman retained the respect of the university as a whole. Only last year the regents of the university bestowed upon him the honorary LL.D. degree.

In Edward Tolman's own behavior at significant choice-points in life there was little evidence of the vacillation that he often found in his rats in a maze. His own behavior at such choice-points was cognitively clear and purposively directed toward the goal of truth and humanity.

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Science in the News

Committee Assesses Dangers That Accompany Government Support of University Research

The American Civil Liberties Union called recently for a nationwide review of the effect on college and university freedom of private and governmental grants for research projects. The question posed by the union in a report of its Academic Freedom Committee was this: "Is it in the interest of society to permit the universities to lose a large measure of their authority in shaping the development of their own affairs?" The report emphasizes that this is a question "of the first importance to the nation and to society, and that developments rendering difficult a wise decision are multiplying at such a rate that no time should be lost in instituting an objective review of the situation on a nationwide scale."

The ACLU committee estimates that at present two-thirds of the expenditures for all research and development performed by colleges and universities comes from the federal government and that in certain fields, such as physics and chemistry, 90 percent or even more of research budget funds are provided by government and private foundation or industry sources.

Some of the Problems

These are some of the problems touching on academic freedom that are discussed in the Civil Liberties Union statement:

1) ". . . The application of government security procedures in universities in which classified research is conducted on campus under contracts with federal agencies can lead to situations in conflict with the personal rights of faculty members, including even those who are not engaged in classified research, and can effectively limit the freedom of the university in applying its own proper criteria in the selection of its staff."

2) "Funds for sponsored research are more readily available in some fields of knowledge than in others, so that important areas of scholarship may be neglected." Continuation of emphasis

on the natural sciences could lead to "a relative impoverishment to the humanities and social sciences which would certainly not occur if the universities and university scholars were permitted free exercise of their own judgments."

3) "Granting agencies are frequently favorably inclined toward ambitious proposals for so-called programmatic research. . . . It is becoming increasingly difficult to develop support and appreciation for the highly individualistic investigator who contemplatively follows the paths into which his idle curiosity directs him. It is from such unplanned efforts that the fundamental advances in scholarship have always sprung. . . . Universities bear a heavy responsibility for fostering the creation of basic knowledge, and we can ill afford to have their staffs and facilities lured by financial inducements into the study of matters of immediacy."

4) The bulk of research funds from nonacademic sources are allotted to institutions with strongly developed research activities and with outstanding scientists who have well-established reputations. This makes it more difficult for other schools to meet competition for staff, students, and financial aid, and more difficult for younger, less known scientists, "who are actually more apt to come forward with original ideas," to obtain sponsors.

Need for Subsidy Recognized

The Union's statement points out that institutions of higher learning already have surrendered a degree of independence by accepting the terms of certain grants, and that these terms, in turn, affect teachers, study, and administration. However, the report recognizes the importance of research subsidy. "Our colleges and universities are irrevocably dependent on the support they have been receiving in the form of sponsorship of research, and indeed this support must continue to increase rapidly in the years ahead." But the dangers of control through subsidy are imminent, the report contends.

"It must be clearly recognized that if outside financing of university research and graduate education, particularly in the natural sciences, continues to follow present patterns, it will inevitably lead to a very serious erosion of university control of university activities. We should face squarely the question as to whether we are prepared to break with the long-established tradition which entrusts to universities a large measure of autonomy in their proper functions of education and research—whether we are prepared to replace a significant fraction of this autonomy by a patchwork control exerted by a variety of bureaus with widely differing aims and interests."

The ACLU report appears in full in the current issue of the American Association of University Professors' *Bulletin*, where it is reprinted not as a statement of policy but rather to call attention to the important problems raised, with the suggestion that large-scale foundation support be given to a study of the situation.

Kitt Peak National Observatory To Be Dedicated Next Week

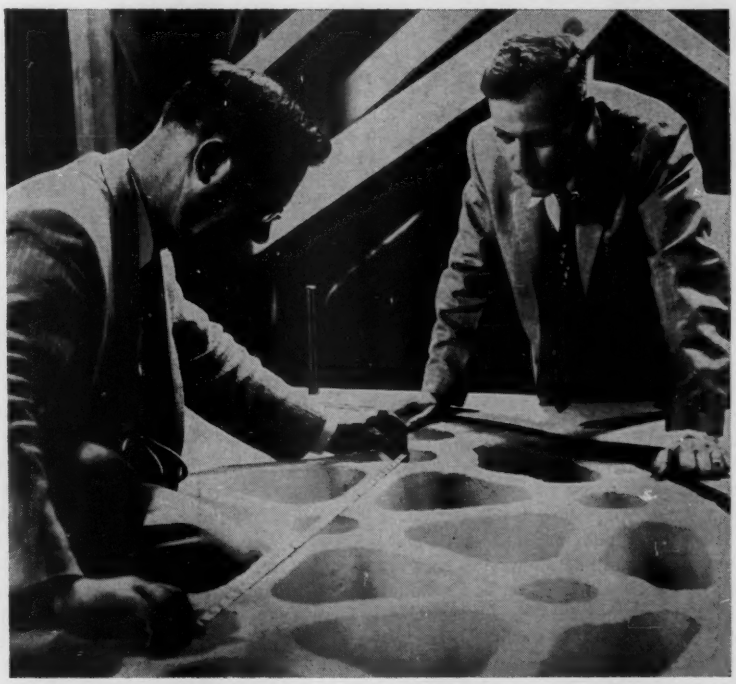
The Kitt Peak National Observatory near Tucson, Ariz., will be dedicated on 15 March, according to Alan T. Waterman, director of the National Science Foundation, which supports the new installation. The dedication will mark the opening of an optical observatory that will be available to all qualified United States astronomers. It is the equivalent for optical astronomy of the National Radio Astronomy Observatory at Green Bank, W. Va., the other national observatory maintained by the National Science Foundation.

Dedication

Prominent scientists and officials of the federal, state, and local governments and representatives of the Papago Indian Tribe, on whose reservation the observatory is located, will take part in the dedication ceremony. Participants will include the National Science Board as well as the Board of the Association of Universities for Research in Astronomy, Inc.. which operates the observatory for NSF. Member universities of AURA now include California, Chicago, Harvard, Indiana, Michigan, Ohio State, Princeton, Wisconsin, and Yale.

The dedicatory address will be delivered by W. W. Morgan of Yerkes Observatory. Waterman, Kitt Peak director Aden P. Meinel, R. R. McMath of AURA, and other guests will also give brief addresses. C. D. Shane of Lick Observatory and president of AURA will preside.

The appointment of Meinel as director of the observatory was announced by NSF in January 1958. He was formerly with the department of astro-



A. B. Meinel (left), director of the Kitt Peak National Observatory, and Arthur Code, of the Association of Universities for Research in Astronomy, Inc., inspect the 84-inch telescope mirror blank cast by Corning Glass Works for the observatory.

physics of the University of Chicago and was an associate director of the Yerkes and McDonald observatories.

Facilities

The first major telescope to go into operation at Kitt Peak will be the 36-inch reflector that has just been installed. Not large by modern standards, it is nevertheless of advanced design, for use primarily as a photoelectric instrument for measuring star brightness. It will be the forerunner of an 84-inch reflector to be completed in 1961 or 1962.

The mirror blank for the 84-inch reflector has recently been delivered to the observatory from Corning Glass Works, Corning, N.Y. The final grinding and polishing are being done by the observatory staff.

Design of a large orbital (satellite) telescope is perhaps the most dramatic project now under way at the observatory. Unlike the specialized, smaller orbital telescopes now being planned by other observatories, this is to be an instrument of high resolving power, to be turned into position on command from earth and to communicate its observations back to earth. An instrument of 50-inch aperture is at present under consideration.

Construction of the orbital telescope is a long-range project, and it is expected that such a large, fully controllable instrument will not be put in orbit for several years. The project was placed under the direction of the Kitt Peak National Observatory both because the size of the effort would probably exceed the capacity of a single university and because it is planned that, once such a telescope is in orbit, it will be a part of the observatory's regular instrumentation and will be available, as are the observatory's other telescopes, to all qualified U.S. astronomers.

The National Science Foundation and the observatory are cooperating with the National Aeronautics and Space Administration at all stages of planning and design of the instrument. Close coordination with NASA's program of astronomy in space is being maintained.

Also being planned is a new solar telescope that will be the world's largest. This instrument will have a parabolic mirror 60 inches in diameter with a focal length of 300 feet, which will produce a solar image several times larger and more brightly illuminated than that attainable by any other ground-based solar instrument.

Oceanographers Will Study Little-Known Swan Islands

This month the Coast and Geodetic Survey's oceanographic research ship *Explorer* will visit one of America's smallest and least-known possessions, the Swan Islands, for a series of studies. The Swan Islands are two tiny strips of land in the Caribbean Sea, 97 miles northeast of Honduras. Thickly wooded Great Swan is about 2 miles long and ½ mile wide. Rocky, inaccessible Little Swan is 1½ miles long and ½ mile wide. Only the larger island is populated.

Oceanographers are particularly interested in the Swans because they lie near the precipitous depths of the Cayman Trough. Coast and Geodetic divers will explore the shelf and sea surrounding the islands. Photographs of animal and plant life will be made, sea water will be chemically tested, and samples of bottom sediment will be taken.

Other Projects Planned

Other projects will be carried out for various government agencies cooperating in the work. A geological survey is scheduled. Deep-sea creatures will be collected for the Fish and Wildlife Service. Specimens of island mammals, reptiles, and insects will be gathered for the Smithsonian Institution. (Some of the animals may go to the National Zoological Park for exhibit.)

Wildlife on the Swans was described by a British archeologist-zoologist who visited the islands in 1938. On Little Swan he saw innumerable booby gannets, so tame they pecked fearlessly at his legs. He also observed frigate birds, many iguanas, and the hutia—the strange, rabbit-sized rodent that nests in jagged rock fissures under prickly bushes. Of the insects, the ants were the worst pests, the Englishman wrote. He suffered some 300 bites that itched for weeks.

Census To Be Taken

Besides its scientific work, the current expedition will take a 1960 census of the Swans for the United States Census Bureau. The 1950 count was made by a member of the Civil Aeronautics Administration on duty there. At the time, 36 persons—mostly men but including a few women and children—were living on Great Swan. Twelve of these had been born in the United States. The others were from other Caribbean islands and from Central America.

The United States acquired sovereignty over the Swans in 1863. Since 1857, when American firms first collected guano for export under the 1856 Guano Act, American interests and personnel manning navigation and communication outposts have continuously used and accupied the islands.

The U.S. Weather Bureau now maintains a meteorological station on Great Swan; the Civil Aeronautics Administration maintains an airways beacon.

President Names New Member of the Atomic Energy Commission

Robert E. Wilson, chemical engineer who retired in 1958 as chief executive officer and chairman of the board of the Standard Oil Company of Indiana, has been named by President Eisenhower to be a member of the Atomic Energy Commission. He will fill the vacancy created in the five-man commission by the death last August of Harold S. Vance. Wilson has been nominated to serve the 4 months remaining in Vance's term and a 5-year term of his own.

The proposed new member has had considerable experience in the activities of the AEC, having served on the commission's general advisory committee since shortly after the commission was created in 1947. Hearings on the nomination by the Joint Congressional Committee on Atomic Energy are expected to be held soon.

With Republicans Wilson and chairman John A. McCone, the commission will have a political make-up of two Republicans, one Democrat (John S. Graham), and two independents (John F. Floberg and John H. Williams). The Atomic Energy Law sets no requirement for the political composition of the commission and, although the Joint Committee has a Democratic majority, appointments to the Atomic Energy Commission are traditionally apolitical. John McCone said recently: "The other commissioners and I are delighted that Dr. Wilson has accepted the President's nomination."

Markle Scholars Named

Twenty-five young medical scientists, all faculty members of medical schools in the United States and Canada, have been appointed Markle Scholars in Medical Science by the John and Mary

R. Markle Foundation of New York. Each appointment carries with it a $30,000 grant, to be paid to the medical school where the scholar will teach and do research. The grant will be spent at the rate of $6000 a year and will be used for the scholar's support and to aid his research for the next 5 years.

There were 58 candidates nominated for the grants by medical schools this year. Five committees composed of educators and other professional men helped to select the 25 scholars, whose appointments will begin on 1 July.

The foundation was established in 1927 by the late John Markle, Pennsylvania coal operator, "to promote the advancement and diffusion of knowledge . . . and the general good of mankind." The scholar in medical science is now the fund's chief object of interest.

The new Markle scholars, most of whom are assistant professors or the equivalent, are as follows:

Gonzalo E. Aponte, Jefferson Medical College of Philadelphia, pathology; J. Thomas August, Stanford University School of Medicine, internal medicine; Dana C. Brooks, Cornell University Medical College, anatomy; Lamar E. Crevasse, University of Florida College of Medicine, internal medicine; John R. Evans, University of Toronto Faculty of Medicine, internal medicine; James J. Ferguson, University of Pennsylvania School of Medicine, internal medicine; and Robert A. Fishman, Columbia University College of Physicians and Surgeons, neurology.

John R. G. Gosling, University of Michigan Medical School, obstetrics and gynecology; Joseph A. Hinke, University of British Columbia Faculty of Medicine, anatomy; Charles H. Hollenberg, McGill University Faculty of Medicine, internal medicine; William D. Huffines, University of North Carolina School of Medicine, pathology; Frank L. Iber, Johns Hopkins University School of Medicine, internal medicine; and Stanley W. Jacob, University of Oregon Medical School, surgery.

Richard C. Lillehei, University of Minnesota Medical School, surgery; James F. Lind, University of Manitoba Faculty of Medicine, surgery; John G. Loesch, University of Illinois College of Medicine, psychiatry; Frank I. Marcus, Georgetown University School of Medicine, internal medicine; David S. Maxwell, University of California (Los Angeles) School of Medicine, anatomy; and Richard L. Naeye, University of Vermont College of Medicine, pathology.

Hubert C. Pirkle, University of Louisville School of Medicine, pathology; Frank R. Schmid, Northwestern University Medical School, internal medicine; Seymour I. Schwartz, University of Rochester School of Medicine, surgery; Daniel B. Stone, State University of Iowa College of Medicine, internal medicine; Ralph J. Wedgwood, Western Reserve University School of Medicine, pediatrics; and G. Rainey Williams, University of Oklahoma School of Medicine, surgery.

New Atomic Weight for Silver Announced by Standards Bureau

A more precise value for the atomic weight of silver has been determined by investigators at the National Bureau of Standards, U.S. Department of Commerce. The new value represents a major achievement in research and could affect the accepted atomic weights of other elements. In redetermining this important constant, a key value for gaging the atomic weights of other elements, the Bureau has obtained a value which differs significantly from that accepted in international scientific circles —107.873, as compared with the value of 107.880 that is now in use.

V. H. Dibeler, who with W. R. Shields and D. N. Craig conducted the research, points out that the experiments included the first comparisons with calibrated samples of known isotopic abundances. The redetermination was made as part of a recent redetermination of the faraday, a basic electrochemical constant.

Fuchs Interviewed in East Germany

Klaus Fuchs, who spent 10 years in British prisons for having given Western atomic secrets to the Soviet Union, is now deputy director of the East German nuclear research station in Rossendorf, near Dresden. Released from jail last summer, Fuchs is devoting himself to studying the reactions of known nuclear particles and directing construction of a pilot plant for industrial atomic energy.

At a recent press interview, when asked whether he would repeat his acts of espionage if he had a second chance, he is reported to have said: "It is hard to say. . . . The Soviet Union is on the right line. It is for peace. Whatever helps the Soviet Union is right."

The *New York Times* article of 18 February in which the interview was described mentions Fuchs' high praise of the young assistants who work under him at Rossendorf. He emphasized that they are "workers' children, educated under our system," and commented: "They would be the exception in capitalist countries. Here, they are the rule."

Like many other research and technical centers in East Germany, the Rossendorf institute has contacts with scientists abroad and exchanges scientific information. However, according to the *Times*, Fuchs expressed regret that there was very little exchange with American scientists, saying: "I hope that much more can be arranged in this direction."

News Briefs

Conquest award. The Columbia Broadcasting System's television program "Conquest," for which the AAAS serves as adviser, has received the 1959 award of the Edison Foundation as "the best science television program for youth."

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History of science. Yale University has announced that a department of the history of science and medicine is being established, which will offer both undergraduate and graduate courses, beginning next September. John F. Fulton, noted neurophysiologist and Sterling professor of the history of medicine, has been named chairman, and Derek J. deSolla Price, British scientist and historian, has been appointed to a newly created professorship in the history of science and has been named curator of scientific instruments. The new department will be part of both the Yale Graduate School and the School of Medicine and will replace the present history of medicine department, which operates chiefly within the medical school.

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Nuclear science institute. Fifty-one students, 47 from 18 foreign countries and four from the United States, are enrolled in the first session of the International Institute of Nuclear Science and Engineering that began last month at the U.S. Atomic Energy Commission's Argonne National Laboratory, Lemont, Ill. The institute replaces the former International School of Nuclear Science and Engineering, organized at Argonne in 1955. The curriculum at

the institute is at a higher professional level than that of the former school. Appointments are on two levels—the "participant" level, which requires the equivalent of a doctoral degree in the ence and engineering earned in the United States and a background in fundamental nuclear studies, and the "affiliate" level, which requires the equivalent of a doctoral degree in the United States.

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Project Talent. A national survey of the aptitudes and abilities of American youth, called Project Talent, began on 1 March. Approximately 1000 school superintendents and 1400 secondary-school principals supervised 20,000 teachers in collecting data on a representative sample of 460,000 students drawn from all of the 50 states. John C. Flanagan is directing the study, which is being conducted by the University of Pittsburgh with financial support from the United States Office of Education and with assistance from the National Institute of Mental Health and the Office of Naval Research. Results of the survey will be reported later this year.

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Symposium on radioactivity. The AAAS Section on Medical Sciences is sponsoring a symposium on "Radioactivity in Man, Measurements and Effects of Internal Gamma Ray Emitting Radioisotopes," to be held at Vanderbilt University 18–19 April. The conference was made possible by a grant from the United States Steel Foundation to the AAAS and is supported in part by the Division of Biology and Medicine of the Atomic Energy Commission, by the Public Health Service, and by the Army Medical Research and Development Command. The symposium chairman is George R. Meneely, School of Medicine, Vanderbilt University, Nashville 5, Tenn.

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Arizona medical school. The Board of Regents of the Universities and State College of Arizona has appointed Joseph F. Volker, as of 1 July, to head the Arizona Medical School Study, which is supported by a grant of $135,000 from the Commonwealth Fund, to determine the state's need for a college of medicine. Volker, who is director of research and graduate study of the University of Alabama Medical Center, will begin immediately to select a staff for the project; the study is expected to require approximately a year.

Grants, Fellowships, and Awards

Biological psychiatry. The Society of Biological Psychiatry is offering an annual award that has been made possible by the A. E. Bennett Neuropsychiatric Research Foundation. The $500 award will be given for a recent, unpublished work; part of the $500 is to be used for traveling expenses to the society's annual meeting, where the paper will be read. Candidates should be fairly young and need not be members of the society. Papers should be submitted in quadruplicate, *before 30 April*, to Harold E. Himwich, M.D., Chairman, Committee of Award, Galesburg State Research Hospital, Galesburg, Ill.

OEEC. The Organization for European Economic Cooperation and the National Science Foundation have announced that the foundation will act as national center in the United States for the administration of the new program of OEEC senior visiting fellowships. The foundation has also announced that applications for the fellowships are now being accepted and that the first awards, approximately 25 in number, will be made to the selected individuals on 23 May.

These OEEC fellowships are intended to assist scientific and technical institutions to incorporate more quickly into their own advanced teaching and research programs the most recent developments in their own and other countries. Ordinarily, the fellowships will be for periods ranging from 8 weeks to 6 months; in exceptional cases a maximum period of 1 year may be approved. The program will cover most fields of the mathematical, physical, biological, and engineering sciences. (Awards will not be made in this program for work in the social sciences or medicine.)

Any public and publicly supported scientific or technical institution or any private training or research institution of a nonprofit character in the United States, its territories, or its possessions may make nominations for these awards. A candidate must (i) be a citizen of the United States as of 9 May, 1960; (ii) have full professional standing in the field with which his fellowship will be concerned; (iii) have at least 5 years' experience in research, teaching, or other relevant professional work; and (iv) have the linguistic abilities necessary for study and profitable discussion with colleagues in the country he proposes to visit.

In view of the sponsorship of this program, it is expected that award recipients, in nearly all cases, will plan to study abroad in a country that belongs to or is cooperating with the OEEC. These countries are Austria, Belgium, Denmark, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.

An OEEC senior visiting fellow will receive a subsistence allowance of $10 for each day of tenure. A travel allowance, covering the cost of round-trip air-tourist transportation to his fellowship institution, will also be provided. In addition, the fellow will be permitted to receive, during the period of his award, his regular salary or appropriate allowances provided by or approved by his nominating institution, or both.

Applications and detailed information may be obtained from the Fellowship Office, National Academy of Science–National Research Council, 2101 Constitution Avenue, NW, Washington 25, D.C. Fellowship applications must be received by the NAS–NRC not later than *11 April*.

Travel in the Far East. An Alan Gregg travel fellowship in medical education is to be awarded annually by China Medical Board of New York, Inc., beginning this year. The fellowship will make it possible for a member of the faculty of a medical school in the United States to undertake study in the Far East that will increase his effectiveness as a medical educator. The fellowship will provide for study and travel expenses; a stipend, the amount to be decided by the Award Committee, will be included. An applicant must be a citizen of the United States and must be at least 30 and not more than 55 years of age when the proposed project is due to start. He must be willing to devote a minimum of 4 months of full-time work to the study project (maximum period, 12 months) and to spend a significant amount of time in one place. When trips are made for periods of 9 months or more, travel funds will be provided for dependent children. Applications for the 1960 fellowship should be submitted *before 15 April* to the Director, China Medical Board of New York, Inc., 30 60th St., New York 22, N.Y. Applications for the fellowship to begin during 1961 must be submitted prior to 31 December 1960.

Scientists in the News

Three scientists are among the five government employees chosen by President Eisenhower to receive the President's Award for Distinguished Federal Civilian Servants—the highest honor conferred on career civil servants.

Hugh L. Dryden, deputy administrator of the National Aeronautics and Space Administration.

Winfred Overholser, superintendent of St. Elizabeths Hospital, Washington, D.C.

Robert M. Page, director of research at the Naval Research Laboratory.

Oswald Tippo, Eaton professor of botany and chairman of the department at Yale University, has been appointed provost of the University of Colorado. Tippo will serve as senior dean and chief academic officer of the university.

The Department of Commerce has conferred Exceptional Service Awards on the following eleven scientists.

Arnold M. Bass and **Herbert P. Broida**, of the National Bureau of Standards in Washington, D.C., for their direction of the free radical research program.

Joel B. Campbell, of the Coast and Geodetic Survey, Washington, D.C., for his work on the United States phase of geomagnetic operations during the IGY.

Garbis H. Keulegan, of the National Bureau of Standards, Washington, D.C., for work on basic laws of hydrodynamics.

Helmut E. Landsberg, of the Weather Bureau, Washington, D.C., for his work on climatology and meteorology.

Alvin G. McNish, of the National Bureau of Standards, Washington, D.C., for contributions in the fields of geomagnetism and ionospheric physics as well as to meteorology and standardization.

Charlotte Moore Sitterly, of the National Bureau of Standards, Washington, D.C., for research in spectroscopy and astrophysics.

Chester H. Page, of the National Bureau of Standards, Washington, D.C. for work in the fields of electronics, ordnance, and physical research and measurement.

John Oscar Phillips, of the Coast and Geodetic Survey, Orlando Air Force Base, Fla., for geodetic surveys in support of missile guidance systems.

Leonardo Testa, of the National Bureau of Standards, Washington, D.C., for aiding scientific research by his work as a creative glass blower.

Harold O. Wyckoff, of the National Bureau of Standards, Washington, D.C., for his work on radiation protection.

Three scientists are among the ten outstanding government workers for 1960 named by the National Civil Service League:

Allen V. Astin, director of the National Bureau of Standards.

Eugene S. Love, assistant chief of the aerophysics division of the National Aeronautics and Space Administration, Langley Field, Va.

Franklin K. Pittman, director of the division of reactor development for the Atomic Energy Commission.

Brig. Gen. B. G. Holzman, commander of the Air Force Office of Scientific Research (AFOSR), has been named commander of the Air Force Research Division.

Colonel A. P. Gagge, vice commander of the AFOSR, will succeed him. **Colonel Raymond A. Gilbert**, deputy for sciences of the AFOSR, is now deputy chief of staff for plans and operations of the Air Force Research Division.

Andrew Huxley, reader in experimental biophysics at the physiological laboratories of the University of Cambridge (England), is visiting lecturer in biophysics at Harvard University during March. He will deliver 13 graduate lectures on nerve and muscle.

Three anthropologists will deliver the Westbrook Free Lectures sponsored by the Wagner Free Institute of Science, Philadelphia, Pa., during April.

Loren C. Eiseley, provost of the University of Pennsylvania, will speak on the world of primitive man, on 14 April.

Carleton Coon, professor of anthropology at the University of Pennsylvania, will lecture on early man in the Old World, on 21 April.

William H. Howells, professor of anthropology at Harvard University, will speak on early man in the New World, on 28 April.

Franz von Lichtenberg, associate in pathology at the Harvard Medical School and the Peter Bent Brigham Hospital, has been awarded an honorary doctoral degree by the National University of Nicaragua, Leon.

Erich Hausmann, retired Thomas Potts professor of physics and dean emeritus of the Polytechnic Institute of Brooklyn, has received the Gano Dunn Medal for Professional Achievement, awarded annually by the alumni association of the Cooper Union for the Advancement of Science and Art.

C. Barnard, principal research officer in the section of genetics, cytology, and structural botany of the division of plant industry in Canberra, Australia, will visit the United States from 27 March to 12 June. His itinerary includes Washington and San Francisco.

A. L. Downing, principal scientific officer of the water pollution research laboratory in Herts, England, will arrive in this country on 19 April for a 3-week visit. His itinerary includes New York, Boston, Ann Arbor (Mich.), Madison (Wis.), Chicago, and Chapel Hill (N.C.).

The final banquet of the annual convention of the American Association of Bioanalysts will honor **Margaret I. Beattie**, who is retiring as head of the laboratory science department of the School of Public Health of the University of California, Berkeley. The keynote speaker will be **Peter H. Forsham**, professor of medicine and chief of the Metabolic Institute of the University of California, San Francisco.

Richard C. Gibson, director of the experimental vehicles and instrumentation division of the Air Research and Development Command, Andrews Air Force Base, Md., has been named professor and head of the department of astronautics at the Air Force Academy.

Charles F. Brumfiel, professor of mathematics at Ball State Teachers College, Muncie, Ind., has been appointed associate professor of mathematics at the University of Michigan.

Samuel P. Hayes, Jr., professor of economics at the University of Michigan and director of the Foundation for Research on Human Behavior, has been appointed chief of the social science department of the UNESCO Secretariat, in Paris, for a 2-year term.

Hollis W. Peter, will succeed him as director of the foundation.

Erratum: On the contents page of the 4 March issue [*Science* 131, 627 (1960)], the title of the report by S. A. Sand should read "Autonomy of cytoplasmic male sterility in grafted scions of tobacco."

Book Reviews

Science and Liberal Education. Bentley Glass. Louisiana State University Press, Baton Rouge, 1960. x + 115 pp. $3.

These three essays, originally given as lectures before a lay audience, are a credit to the profession. Scientific principles are explained with simplicity and accuracy, and the importance of science in liberal education is well argued. References to many artists and scholars from "the other side" are wisely utilized. The historian Carl Becker figures prominently.

Bentley Glass insists that science must become the core of liberal education, but aptly reminds us that "The core of the apple is certainly not the whole apple—not even the most beautiful or delicious part of the apple. Yet the core gives the rest of the apple meaning—here lie the seeds without which, in a state of nature, there would be no more apple trees and no more apples" (page 63). That portion of the educational core that we call genetics is discussed at length. Radiation problems are admirably summarized.

Evolutionary and genetic theory are serious challenges to traditional ethics. The author points out how well-meaning tenderheartedness with respect to animals has frequently led to actions that are cruel because they are based on insufficient information—for example, when man removed such "cruel" predators as wolves and coyotes, he made it possible for their ungulate prey to multiply to the point where they can enjoy the delights of mass starvation. In the human species, medicine, attempting to save all life by correcting for individual "inborn errors of metabolism" without removing their genetic causes, raises the potentiality of increasing the total amount of suffering as harmful mutations are summed, generation after generation. Glass rightly asks if traditional medicine is not acting in such a way as "to damn the future for the selfish interest of the present?" (page 113). Yet, so difficult is it even for biologists to keep in mind the dilemma in choosing between present and future evil that even our geneticist, in speaking of the consequences of shifting from exogamy to endogamy, says that if we should revert to the earlier breeding pattern the result would be a "disastrous increase in the proportion of hereditarily afflicted persons" (page 44); he says this in spite of the fact that on the preceding page he had admitted that "inbreeding does not of itself change gene frequencies, but it brings the recessive genes out into the open and allows selection to be exercised upon them." Is this "disastrous"? I do not want to be cited as a proponent of cousin-marriage, but as scientists we must insist that *as concerns society* there is, perhaps, as much to be said for inbreeding as against it, since it results in paying off genetic debts early rather than late; only the individual parent benefits by exogamy, since he thereby shuffles off his genetic debt onto a later generation. Ethics is a difficult discipline.

Nevertheless, there are no important objections to be made to Glass's presentation, which contains much that deserves praise. His book well merits wide reading among the general public. It should be particularly effective in arousing the interest of high-school students in the social implications of science; it should help to bring together what C. P. Snow has called the "two cultures" of science and the other humanities.

GARRETT HARDIN
University of California, Santa Barbara

Political Man. The social bases of politics. Seymour Martin Lipset. Doubleday, New York, 1960. 432 pp. $4.95.

This book is a collection of Lipset's essays, selected by the author to illustrate "the contribution the sociologist can make to the understanding of democratic political systems." It is an interesting demonstration.

The successive chapters present a series of major hypotheses, of which the following examples may indicate the intellectual problem of the book. (i) Democracy requires institutions which support conflict and disagreement as well as those which sustain legitimacy and consensus; (ii) the social situation of the working class predisposes the class to the development of authoritarian attitudes and to a preference for extremist and doctrinaire political movements; (iii) recent fascist movements have represented an extremism based on the political center and the middle class, rather than on the right or left; (iv) in every modern democracy political parties basically represent a "democratic translation of the class struggle."

The method by which Lipset undertakes to establish the validity of these propositions is that of comparative analysis. He has assembled a formidable array of evidence regarding voting and other political behavior, using election statistics, sample survey data, and other records from a dozen different Western democracies. The many regularities he finds in these cross-national comparisons are impressive. His positive style of statement may occasionally imply a clearer order in his evidence than someone else might find, but this is, perhaps, inevitable in an attempt to organize a range of events as broad as he deals with.

Lipset is explicitly committed to the premise that democracy is not merely the means through which different groups "seek the good society; it is the good society itself in operation." He feels that in the West the fundamental political problems have been solved, that the ideological class struggle which formerly divided intellectuals into right and left has lost its driving force. The argument now is over adjustments within a rather narrow range of alternatives. He ends his books with an expression of hope that his attempt to outline the conditions of the democratic order may help "men develop it where it does not now exist," specifically in Africa and Asia.

It is easy to share Lipset's concern that, in this country's attempt to foster the growth of democratic political forms in the so-called underdeveloped nations, those individuals who make our national policies should have some understanding of society and of democracy. There is some question, however, about how well we can understand political man in these countries

from our observation of his behavior in the West. It is obvious that different systems of ownership, employment, mobility, status, and authority will require some adaptation of the concepts which Lipset has found useful in this book. This does not in the least invalidate his concern for the development of a sociology of politics; it merely projects it onto a broader stage.

ANGUS CAMPBELL
Survey Research Center, University of Michigan

The Transits of Venus. A study of eighteenth-century science. Harry Woolf. Princeton University Press, Princeton, N.J., 1959. xiii + 258 pp. Illus. $6.

Now that our age is designated as that of the Sputnik almost as often as it is designated that of the atom, it is interesting to reflect that astronomy, and not physics, has customarily been the trail-blazer of science for some 3000 or 4000 years. For less than a century of that time, physics has seemed to be the leading part of the research front, and astronomy has been relegated to subservience.

In earlier times, the roles were very different. Ptolemaic astronomical theory arose long before any comparably advanced mathematical formulations in the rest of physics. In the later Middle Ages and Renaissance, it was again astronomy that yielded the greatest and most shaking advances. A more equal balance was attained during the age of Galileo and Newton, but within a century of the death of Newton, the new science of electricity had shifted the scientific focus toward what is now known as physics.

This 18th century saw, however, two important astronomical events—the transits of Venus—that had considerable effect upon the organization and the content of the whole of science. It is most interesting that the transits happened when they did by virtue of the *force majeure* of slow astronomical motion rather than by any historical persuasion. The transits of Venus occur at intervals of about eight years, separated by gaps of 105½ and 121½ years, when no such phenomenon can be observed. In the 17th century they happened in 1631 and 1639. The former, but a generation after the development of the telescope, was not seen by anyone. The latter was observed only by Horrox, but no useful measurements were made. The next pair of transits, in 1761 and 1769, became the object of an endeavor similar in nature to the recent International Geophysical Year.

The importance of these transits was that they provided a means for measuring the size of the planetary system —one of the fundamental constants of the observed world. A yardstick for the universe is difficult to obtain. Before high-precision instruments were available, it was not possible, except through the transits of Venus, to obtain any but very approximate results. The transits of Mercury were not very useful, since that planet is too near the sun for much parallax to be observed against the solar backdrop. No other planet will suffice; no other method was possible in the 18th century. Astronomers had to sit patiently and wait for the great events of 1761 and 1769. Wait they did, and when the time came, the astronomers were strung out over the war-torn globe in accessible and almost inaccessible places.

The story of this international essay in science is a most exciting one, and has been admirably told by Harry Woolf. His treatment is monographic and authoritative. Among several entertaining stories is that of Pingré, who made observations on the island of Rodrigue. He improvised turtle oil for cleaning his corroded instruments, and finished by commenting on the excellence of turtle liver as a gastronomical delicacy. Although the historical discussions are so capably written, one might wish that more space had been devoted to the hard core of astronomical theory. Figure 2, which attempts to illustrate the geometry of a transit, appears to be drawn in two planes at once; the letter g should be a q, and this correction should also be made in the text. Furthermore, the letters e and w in the diagram are seemingly irrelevant and unused. The use of Bode's law is misleading in its context, since only Kepler's third law was needed, and indeed used, to obtain the relative distances of Venus and the Earth. There is no theoretical comment on the way in which the early astronomers were forced to abandon the possibility of using the transits of Mercury, and there is little appreciation of the huge difficulties involved in the mathematical technique needed to trace the predicted observabilities of the Venus transits at various points on the Earth. Thus, although the book could have contained more discussion of science from the inside, Woolf has done such a monumental job of editing, collecting, and commenting from the historical outside, upon the original sources related to this episode of science that he shall forever have our thanks and our heartfelt praise for his labors.

DEREK J. DESOLLA PRICE
Department of History of Science and Medicine, Yale University

Crystal Chemistry of Simple Compounds of Uranium, Thorium, Plutonium, and Neptunium. E. S. Makarov. Translated from Russian by E. B. Uvarov. Consultants Bureau, New York; Chapman and Hall, London, 1959. iii + 145 pp. Illus. $5.25.

This book has the two-fold purpose of presenting, in a systematic collection, the results of the many studies of the crystal structure of the chemically simple compounds of uranium, thorium, plutonium, and neptunium, and of developing and correlating the crystal chemistry of these compounds. A brief introduction stating the purpose of the book is followed by chapter 2 (21 pages) in which an attempt is made to present a short discussion of some of the main principles of crystal chemistry. Presumably this chapter is included to make the book more nearly self-contained. It would have been better had the author chosen, instead, to refer his readers to the standard texts on crystal chemistry, since his treatment is very naïve, and in part, completely erroneous. The following statement is one example of this: "In crystals with ionic bonding the valence electrons are completely localized in the atomic orbits of the anions and therefore the negative charge (electron density) is distributed periodically, roughly speaking, at lattice points." This is "roughly speaking" indeed! Many other misleading or completely wrong statements occur in this chapter, including the common mistake of calling the CsCl-type structure body-centered, and, as always, confusing the lattice with the structure.

In chapter 3 (16 pages) data on the crystal structure of the several polymorphic varieties of the elements are collected, and in chapter 4 (72 pages) similar data are given for a large number of simple compounds, including

metallic phases, borides, oxides, hydrides, and halides. In chapter 5 (5 pages) the crystal radii of the actinides are discussed, and in chapter 6 (18 pages) the rival "actinide" and "thoride" hypotheses for the explanation of the chemical behavior of the elements are considered. A detailed table of contents and a list of the literature cited are given, but no index is included.

The strength of this book lies in the fact that it does collect in one place a great many factual data, and for this reason it should be very useful to persons interested in the subject covered. On the other hand, throughout the book the theoretical or interpretive parts are very poor.

C. L. CHRIST
U.S. Geological Survey, Washington, D.C.

The Viruses. Biochemical, biological, and biophysical properties. vol. 2, *Plant and Bacterial Viruses.* F. M. Burnet and W. M. Stanley, Eds. Academic Press, New York, 1959. xvi + 408 pp. Illus. $13.

This book is the second of a three volume series written and edited by scientists who are authorities in their several fields. Volume 2, *Plant and Bacterial Viruses*, contains ten essays, four devoted to the plant viruses and six to the bacteriophages. The book differs from a collection of reviews, which might be garnered from other sources, in that each author has made a conscientious effort to present his subject as a whole without placing special emphasis on his own contributions to it. The book differs from an old-fashioned textbook, written by a single author, in that each chapter is suffused by intellectual and factual local color that seldom emerges from the laboratory except in monograph form.

Wildman introduces the plant viruses by describing the growth of tobacco mosaic virus in plant tissues. Markham writes a monumental chapter on the chemistry of plant viruses, which serves both as a handbook on purification and analysis of virus particles and as a review of pertinent theoretical principles. Knight's chapter on hereditary variation and its chemical correlates among mosaic viruses summarizes this pioneering but, so far, relatively unrewarding topic. The presentation is marred by confusing ellipses involving the use of the word *strain*. Black reviews the evidence from which it has been concluded, in recent years, that certain viruses multiply both in their plant hosts and in their insect vectors, a glaring exception to the rule of host specificity in viral growth.

The bacteriophages are introduced by Lwoff in a chapter that defines the place of viruses among other things and bacteriophages among viruses by a wry and slightly perverse logic that recalls to mind the schoolmasters of fiction. The main features of bacteriophage infection are then described in detail by Garen and Kozloff (initial steps), Stent (intracellular multiplication), Levinthal (genetics), and Jacob and Wollman (lysogeny). Each of these chapters is factually comprehensive, thoughtfully interpretive, and uncluttered by controversial issues. The radiobiology of bacteriophages, summarized by Stahl in a final chapter, can be regarded, for reasons explained by its author, as a subject unconnected with the rest of the book. (Stahl perhaps exaggerates; almost the same accusation concerning genetics is made and rejected by Levinthal in his chapter. The facts are that satisfying connections between these subjects and chemistry remain to be made.) Stahl's chapter is unique in other respects, even among the chapters of this excellent book; the elegently conceived, clearly and economically presented, subject matter might lead the unguarded reader to suppose that writing it was an easy task. As an amateur writer sometimes interested in radiobiology, I can assure him that it wasn't.

The book will need no recommendation to virologists; it may be recommended to all who wish to become virologists, and it will serve as a convenient reference source for others.

A. D. HERSHEY
Carnegie Institution of Washington, Department of Genetics, Cold Spring Harbor, New York

Minerals of New Mexico. Stuart A. Northrop. University of New Mexico Press, Albuquerque, rev. ed., 1959. xvi + 665 pp. 1 map. $10.

This revision is the transformation of an inexpensive, paper-bound bulletin into a 665-page, cloth-bound volume. In its original form *Minerals of New Mexico* was useful to mineralogists and mineral collectors traveling in New Mexico. The new version should be of broader interest. Stuart Northrop has made extensive additions to the 1942 text. He has brought old descriptions up to date by adding the names of new localities, and he has added enormously to the number of minerals discussed by including localities discovered in New Mexico as a result of intensified mining and studies of minerals in the war and postwar years.

Interest in the new addition will be more than local, for the book contains many unpublished facts that Northrop has learned by personal correspondence, and reports he has abstracted from publications that a geologist compiling a bibliography might not encounter. The descriptions of some minerals have grown: calcite takes 13 pages instead of 7, carnotite 2 instead of ½; tyuyamunite, a new addition, covers a whole page. At the end, we find an extended bibliography and list of mining districts. The revision, an ambitious undertaking, is justified by the results, for the book is now of much greater value to general readers than before.

F. H. POUGH
4680 Independence Avenue, New York, New York

90° South. Paul Siple. Putnam's, New York, 1959. 384 pp. $5.75.

On 18 September 1957 the temperature at the United States' IGY Station at the South Pole reached a record low in man's experience, −102.1°F. It was officially recorded by the first 18 scientists and navy men to live and work through man's first winter at 90° South. Paul Siple, internationally recognized as one of America's most versatile scientists, was the scientific leader at this remote scientific outpost, established in a forbidding environment of nothing but snow, wind, and flesh-splitting cold.

This saga of modern scientific exploration is brought into preliminary focus by a perceptive, historical chronicle of man in Antarctica since the continent was first sighted. Then, with undertones of tolerance and magnanimity, Siple recounts the story of the conception, planning, construction, and operation of the station during its first year, against the background of how this was made possible through the concerted national efforts of our armed forces, scientists, and industry.

Siple, a veteran of four antarctic

winters, has participated in both eras of exploration; he counters the tendency of many operational and scientific specialists to disparage "old explorers" by showing the interpendent role of the explorer-scientist in any scientific pursuit: "for the explorers who go into an unknown area to uncover the existence of land are primarily concerned with giving a first approximation of *what* exists rather than precisely *where* it exists. It is the duty of those who come later to locate precisely what is there and where it is. Unfortunately, the almost inevitable poor positioning of the first explorers is invariably the target of criticism by these latecomers, concerned with filling in the details of geology and geography. Both groups are vital to the process of exploration!" Readers may mentally add—and to scientific progress.

GERALD PAGANO
U.S. Army Research Office, Washington 25, D.C.

New Books

Atmospheric Diffusion and Air Pollution. vol. 6, *Advances in Geophysics.* F. N. Frenkiel and P. A. Sheppard, Eds. Academic Press, New York, 1959. 488 pp. $12. Proceedings of a symposium held at Oxford, England, 24–29 August 1958, and sponsored by the International Union of Theoretical and Applied Mechanics and the International Union of Geodesy and Geophysics.

The Chemical Analysis of Air Pollutants. Morris B. Jacobs. Interscience, New York, 1960. 448 pp. $13.50.

College Physics. Francis Weston Sears and Mark W. Zemansky. Addison-Wesley, Reading, Mass., ed. 3, 1960. 1047 pp. $9.75.

Dreams and Personality Dynamics. Manfred F. DeMartino. Thomas, Springfield, Ill., 1959. 394 pp. $10.50.

Encyclopedia of Medical Syndromes. Robert H. Durham. Hoeber-Harper, New York, 1960. 642 pp. $13.50. The *Encyclopedia's* stated purpose is "to present in an editorial style a comprehensive reference text of medical syndromes with an accompanying list of correlated synonyms." The result is an alphabetically arranged, cross indexed list of approximately 1000 syndromes. The description of each syndrome is followed by reference to key literature; descriptions vary in length from a single line to more than a page. The index is arranged by classifications: allergic syndromes, connective-tissue disorders, and so forth.

Essentials of Healthier Living. Justus J. Schiffers. Wiley, New York, 1960. 343 pp. $5.50.

Geologic Names of North America Introduced in 1936–1955. Bull. 1056-A. Druid Wilson, William J. Sando, Rudolph W. Kopf. U.S. Geological Survey, Washington, D.C., 1959. 405 pp. $1. The *Lexicon of Geologic Names of the United States* was published in 1938 and reprinted in 1951 and in 1957. This bulletin is the first step in revising the lexicon; North America, including Greenland and the West Indies, the Pacific Island possession of the United States, and the Trust Territory of the Pacific Islands are included.

Histochemistry. Theoretical and applied. A. G. Everson Pearse. Little, Brown, Boston, Mass., ed. 2, 1960. 1008 pp. $20.

The New Frontier. Man's survival in the sky. K. G. Williams. Thomas, Springfield, Ill., 1959. 169 pp. $5.50.

Severdrup's Arctic Adventures. T. C. Fairley. Longmans, Green, New York, 1960. 317 pp. $6. This book was adapted from *New Land: Four Years in the Arctic Regions,* 1904. Fairley has added some new chapters.

Strange World of the Moon. An inquiry into its physical features and the possibility of life. V. A. Firsoff. Basic Books, New York, 1960. 236 pp. $6.

Tukani. Helmut Sick. Translated by R. H. Stevens. Eriksson-Taplinger, New York, 1960. 240 pp. $5. Translated from *Tukani* published by Paul Parey, Hamburg, 1957.

The Zoological Record. vol. 93. G. Burder Stratton, Ed. Zoological Society of London, London, 1959. 20 sections. £8. This annual volume comprises 19 sections, which, with the exception of the section on comprehensive zoology and the list of new genera and subgenera, record the literature relating to a class or phylum of the animal kingdom. In addition to the bound volume, each section is published separately as soon as it is completed—for example, the Aves section of volume 94 was published on 16 September 1958, and that of volume 95 on 11 October 1959.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed not to Science, *but to the publisher or agency sponsoring the publication.)*

British Museum (Natural History). *Bulletin,* Entomology, vol. 8, No. 5, *The Walker Types of Fruit Flies (Tephritidae-Diptera) in the British Museum Collection,* D. Elmo Hardy, 84 pp. 30s. Historical Ser., vol. 2, No. 1, *Darwin's Journal,* Gavin de Beer, Ed., 22 pp., 8s. Historical Ser., vol. 2, No. 2, *Darwin Notebooks on Transmutation of Species;* part 1, *First Notebook (July 1837–February 1838),* Gavin de Beer, Ed., 1960. *The John Murray Expedition, 1933–34, Scientific Reports,* vol. 10, No. 5, *Sponges,* Maurice Burton, 130 pp. £2; vol. 10, No. 6, *Report of the Brachiopoda of the John Murray Expedition,* Helen M. Muir-Wood. 36 pp., £1, 1959. British Museum (Natural History), London.

Institute pour la Recherche Scientifique en Afrique Centrale. *Eleventh Annual Report.* 1958. The Institute, Brussels, Belgium, 1959. 375 pp.

Institute of International Education. *Thirty-ninth Annual Report.* 1 January 1958–30 June 1959. Institute of International Education, New York 21, 1959. 64 pp.

International Geophysical Year, 1957–58, United States Program. Report of the U.S. Committee. Stanley Ruttenberg, Ed. IGY World Data Center A, National Acad. of Sciences, Washington 25, 1960. 90 pp. $1.

Mental Health Problems of Automation. Report of a study group. WHO Tech. Rept. Ser. No. 183. World Health Organization, Geneva, 1959 (order from Columbia Univ. Press, New York). 30 pp. $0.30.

National Academy of Sciences–National Research Council, Office of Scientific Personnel. Tech. Rept. No. 15, *Validation of Fellowship Selection Instruments against a Provisional Criterion of Scientific Accomplishment.* Lindsey R. Harmon. 10 pp. Tech. Rept. No. 16. *Effects of a Summary Score on Panel Judgements.* Herbert Soldz. 13 pp. *Report of the Conference on Chemical Compounds of Certified High Purity.* Sponsored by the Academy–Council and the National Science Foundation, 22–23 June 1959. 62 pp. National Academy of Sciences–National Research Council, Washington 25, D.C.

National Science Foundation. *Ninth Annual Report, 1959.* National Science Foundation, Washington, D.C. (order from Supt. of Documents, GPO, Washington 25).

The Nth Country Problem and Arms Control. A statement by the NPA special projects committee on security through arms control and a technical report written by William C. Davidon, Marvin I. Kalstein, and Christoph Hohenemser. National Planning Assoc., Washington, D.C., 1960. 62 pp. $1.

Natural Aerosols and Nuclear Debris Studies, GRB Research Notes, No. 24, M. I. Kalkstein *et al.,* 36 pp. *Global Fallout and Its Variability,* Geophysical Research Paper No. 65, E. A. Martell, 26 pp. *Scientific Studies at Fletcher's Ice Island, T–3,* 1952–1955, vol. 1, Geophysical Research Papers No. 63, Vivian Bushnell, Ed. Air Research and Development Command, Bedford, Mass., 1959 (order from U.S. Department of Commerce, Office of Technical Services, Washington 25).

Occurrence and Biological Effects of Fluorine Compounds, Annotated Bibliography. vol 1, books 1 and 2, *The Inorganic Compounds.* Irene R. Campbell and Evelyn M. Widner. Univ. of Cincinnati, Ohio, 1958. 995 pp. $25.

The Puerto Rican Population: A Study in Human Biology. Frederick P. Thieme. Univ. of Michigan, Ann Arbor, 1959. 200 pp. $2.50.

Qualifications and Teaching Loads of Mathematics and Science Teachers. Circular No. 575. Kenneth E. Brown and Ellsworth S. Obourn. U.S. Office of Education, Washington, D.C., 1959. 101 pp. $0.70.

Quality in Laboratory Animals. Report of a symposium. Laboratory Animals Centre, Collected Papers, vol. 8, M.R.C. Laboratories, Woodmansterne Rd., Carshalton, Surrey, England, 1959. 68 pp. 10s.

Survey of Geology-Geophysics Students in the Colleges and Universities of United States and Canada in 1958–59. Compiled by Bonnie C. Henderson. American Geological Institute, 2101 Constitution Avenue, NW, Washington 25, 1959, 23 pp. $0.50.

Reports

Thrombin-E as a Fibrinolytic Enzyme

Abstract. Thrombin-E has been produced in adequate quantity for pharmacological studies. After intravenous infusion in dogs there were no significant changes in blood pressure, temperature, pulse rate, and respiratory movements. There were drops in platelet and white cell count, and there was an increase in blood-sugar level. Powerful fibrinolytic phenomena were observed.

The recent discovery of thrombin-E followed from observations of the properties of thrombin and experiments on the activation of prothrombin (*1, 2*). First, the observation that thrombin preparations have both the power to clot fibrinogen and also the power to dissolve a clot (*3*) needed further clarification, since the lytic power might reside with a contaminating enzyme and not with the thrombin (*4*). This objection was removed when thrombin was produced as a purified enzyme and found to contain lytic and clotting properties (*5*). However, when certain thrombin solutions were allowed to stand, the clotting power could be seen to disappear while much of the lytic activity remained (*1*). Such thrombin was called esterase thrombin or thrombin-E, to distinguish it from thrombin-C (clotting thrombin), which is the classical thrombin.

By studying the activation of prothrombin, conditions were found wherein practically only thrombin-E activity developed. In all activations studied, thrombin-E arose in greater concentration than thrombin-C (*6*). In other words, thrombin-E activity develops first, and thrombin-E is an enzyme distinctly different from thrombin-C. With regard to substrates, thrombin-E uses fibrin and *p*-toluenesulfonyl - L - arginine - methyl ester (TAMe) but not fibrinogen. Thrombin-C, on the other hand, uses fibrin, *p*-toluenesulfonyl-L-arginine-methyl ester, and fibrinogen as a substrate. To state this another way, thrombin-C clots fibrinogen and subsequently dissolves a fibrin clot. Thrombin-E does not clot fibrinogen but dissolves fibrin clots.

One of the problems with which we were confronted was the need for producing thrombin-E free of any significant amounts of thrombin-C. This was eventually accomplished by acetylating thrombin-C with acetic anhydride (*7*). This blocked, among others, the amino groups of the N-terminal glutamic acid residues, and the thrombin-C lost its clotting power. One of the gratifying observations was the almost doubling of thrombin-E activity as the thrombin-C activity was destroyed. The acetylated thrombin was obtained as a single component, which can readily be dried from the frozen state and generally seems to be quite stable.

Thrombin itself has been found useful in certain instances where anticoagulant drugs were ineffective in the treatment of thrombosis (*8*). This is all the more remarkable in view of the clotting potential of the enzyme. Evidently this was kept under control by using only small amounts and by using them slowly. Since we had thrombin-E as acetylated thrombin there was no risk of producing intravascular clots, but the question was whether any lytic power would be noticed upon intravenous infusion. It was at once evident that this property is exhibited to a very substantial degree by acetylated thrombin when given to dogs.

In our work bovine thrombin was purified (*5*) and acetylated with acetic anhydride. The acetylated thrombin was separated and assayed with *p*-toluenesulfonyl-L-arginine-methyl ester as a substrate. It was practically devoid of clotting power, and could be given intravenously without promoting the formation of clots. Many experiments have been performed, and the following one is typical. About 15 mg of thrombin-E, dissolved in 100 ml of physiological saline solution, was infused (through the femoral vein of a dog under pentobarbital anesthesia) slowly over a period of 1 hour. The dog tolerated this very well. The blood pressure, temperature, pulse rate, and respiratory movements all remained unaltered.

Blood samples were repeatedly withdrawn and analyzed. At the conclusion of the infusion the blood sample clotted, but it subsequently lysed within an hour. The leukocyte count dropped from 9000 to 1500 per microliter and the platelet level was also down, but no changes in red cell count were found. Of the several chemical analyses performed on the plasma the one which showed a rise in blood-sugar level was the most unusual: the original concentration was approximately doubled. All these manifestations persisted for some time, but in 24 hours all values were again at normal (preinfusion level), the return to normal being already noticeable in 6 hours. Occasionally the lytic phenomenon was so pronounced that the blood would not clot spontaneously upon withdrawal or even after thrombin was added.

In test tubes, thrombin-E, in the form of acetylated thrombin, does not have especially rapid action as a fibrinolytic agent. When given intravenously, however, a spectacular result is obtained. It may be that the thrombin-E functions by activating physiological processes concerned with fibrinolysis. This opens possibilities for the useful application of thrombin-E, which can probably be made from bovine sources owing to the low precipitinogenic qualities of bovine thrombin (*9*). An interesting theoretical consideration relates to the view that thrombin-E might be derived from prothrombin in our normal physiology to help maintain the fluidity of the blood—a view based on the possibility that thrombin-E is derived from prothrombin before thrombin-C in the prothrombin activation sequence (*10*).

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10. This work was supported by grant No. H-3424 of the National Heart Institute U.S. Public Health Service.

9 November 1959

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

Natural Radioactivity of Miami Soils

Abstract. An important part of man's radioactive environment is the natural radioactivity of soils. This radioactivity varies with soil type and with depth in the soil profile. The relation between gross gamma activity and soil depth for a particular soil (Miami silt loam) is presented, together with a discussion of the contribution of K^{40} and the uranium and thorium series and of the effects of fallout from bomb tests in increasing the radioactivity of a thin layer of surface soil.

The presence in trace amounts of natural radioelements in the soil has long been recognized as a factor in our radioactive environment. In 1912 Rutherford (*1*) discussed radium and thorium as sources of radioactivity in soils. Not until recently, however, has much progress been made in evaluating and understanding such radioactivity. Gibbs and McCallum (*2*) in 1955 studied the gamma and beta radioactivity of certain New Zealand soils and found that radioactivity measurements in the field were useful in classifying and identifying different soil types. Gustafson, Marinelli, and Brar (*3*) in 1958 reported on a study of the natural radioactivity of soil in relation to fallout and demonstrated that the fission products in fallout then contributed only 7 mr/yr to the total background dose rate for points 3 ft above the ground, as compared with 77 mr/yr for the natural radioactivity of soil.

The role of soil and rocks in the circulation of radioactive isotopes in the biosphere was recently discussed by Arnold and Martell (*4*). The distribution and abundance of uranium, thorium, and potassium in various types of rocks in the earth's crust are discussed in *Nuclear Geology* (*5*).

Our interest in radioactivity in soils was aroused by James Thorp, who became aware of such radioactivity as a possible tool for classifying soils during a visit in Australia in 1956. It has been our purpose, since then, to learn more about the natural radioactivity of soils, its variation with soil type and throughout the soil profile, the sources of radiation and their relative contributions, and the distribution of various radioelements in relation to the gradual development of a soil profile from the parent soil material (*6*).

Preliminary attempts to detect and measure the radioactivity of local soils by means of a survey-type gamma scintillator (type 111C Precision Instrument scintillator) revealed small but detectable differences. Experience led us to conclude that making measurements in the field with a survey-type meter is attended by rather serious difficulties. In the absence of heavy shielding the count rate is measured from a large and heterogenous body of soil. When a large body of soil is involved, self-absorption effects become important, but are difficult to evaluate. Also, the upward diffusion of radon from deeper layers may obscure readings close to the surface. Another complication in making field measurements is the variable amount of background radiation arising from radon in the atmosphere. The radon content of the atmosphere varies with wind velocity, atmospheric pressure, and relative humidity. Thus it would seem difficult to interpret field measurements such as those reported by Lieftinck (*7*).

Making measurements with a scintillator probe and scaler in the laboratory proved to be a more sensitive method and provided better control of the variables involved. Our present method is based on counting gamma radiation from a 1-kg soil sample. Samples are placed in a can consisting of an inner cylinder which surrounds a crystal approximately 2 in. in diameter and 2 in. high, and an outer cylinder 5 in. in diameter. A lead shield was designed and constructed to enclose probe and sample. By this means a total count-to-background ratio of approximately 5 to 1 was achieved, and 10-minute counts could be reproduced to within 3 or 4 percent. All pulses above 100 kev were passed through a discriminating circuit and counted by a scaler.

Samples were identified in the field as to soil type and soil horizon. Each sample was crushed, passed through a screen of 0.25-in. mesh, and thoroughly mixed. A sufficiently large portion was withdrawn to provide 1 kg after oven-drying overnight at 105°C. Counting was started within 5 minutes after the sample had been removed from the oven, weighed, and sealed in the can with electrical tape. After this first counting, each sample, still sealed, was set aside, counted again 1 week later in order to determine the increase in count rate because of radon build-up.

The solid line (1959) in Fig. 1 represents the relative gamma activity in net counts per minute as a function of depth below the surface for Miami silt loam soil. Samples were taken in April 1959 from a woodland approximating a virgin forest. The dotted line (1950) represents the same relationship for soil dug from the same site 9 years earlier. The displacement between the solid line and the dashed line (1959, radon) corresponds to the increase in count rate caused by the accumulation of radon in the sealed cans during a 1-week period. The contrast between the 1950 and 1959 gamma activity of the undecayed surface litter (A_{oo}) and the decayed surface organic matter (A_o) shows that the fission products in fallout from bomb tests are effectively filtered by the surface layers, even though some penetration to a depth of 3 or 4 in. is indicated. A gamma spectrum of the recent A_{oo} and A_o activity positively identified the source as fission products of fallout nuclei.

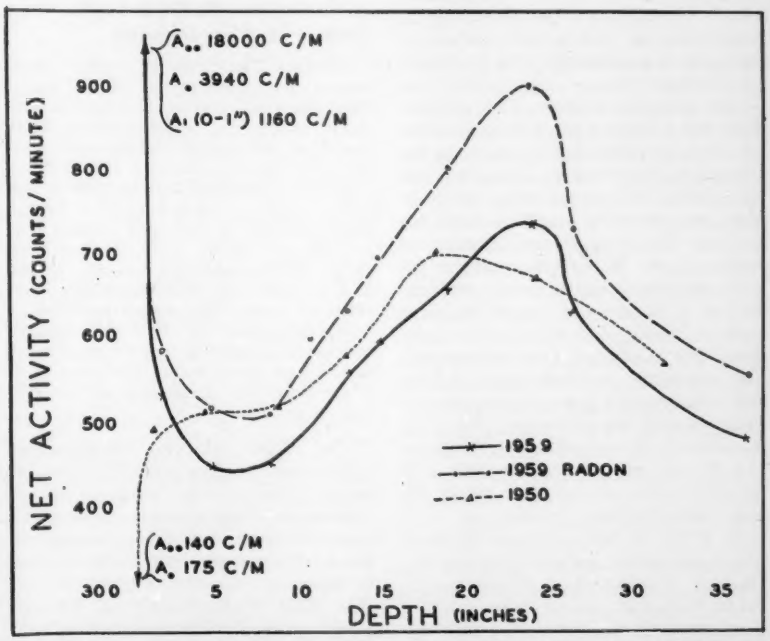

Fig. 1. Gamma radioactivity of Miami silt loam at various depths in the soil profile. A_{oo} refers to the undecomposed, and A_o to the decomposed, vegetable matter at the surface of the soil. The transition from horizon A to horizon B occurs at about 12 to 13 in. and that from horizon B to horizon C, at about 25 to 26 in.

The accumulation of radon in the sealed cans was scrutinized more closely by taking daily counts on a sealed sample from the lower B horizon (19- to 25-in.) during a 3-week period. The rise in count rate followed very closely an inverted decay curve with the characteristic half-life of radon (3.8 days).

A series of chemical analyses of total potassium as a function of depth were made by Donald Coonrod (values lay within the range 1.48 to 1.83 percent). A close correlation was found between total potassium content and gamma activity versus soil depth (the confidence limits were 0.986). We therefore calibrated the counting equipment for potassium. Our method was suggested by Gustafson, Marinelli, and Brar (*3*) of the Argonne National Laboratories. A "mock soil" was made by mixing enough KCl into uncontaminated sodium phosphate to give the same mass of potassium as that contained in one of the 1-kg soil samples and to give the same counting geometry. The counts obtained in this way were interpreted as counts from soil potassium only. By this method we concluded that the radioactive isotope of potassium (K^{40}) accounts for about 21.3 percent of the total count in the A horizon, 19.3 percent in the B, and 18.5 percent in the C. It seems highly probable that the remaining 78.7 to 81.5 percent of the count arises from radioelements of the uranium and thorium series. The emanation of radon (Rn^{222}), previously mentioned, can arise only from radium, (Ra^{226}), but because of soil leaching and weathering the radium will not necessarily be in equilibrium with its longer-lived parents.

The increased count rate as one goes from the A through the B horizon would appear to be accounted for partly by the greater concentration of potassium, and therefore of K^{40}, in the lower soil horizons and partly by a similar trend for radium. The greater accumulation of radon in the B horizon must be accompanied by a higher radium concentration. This was not expected, since radium is known to behave chemically somewhat as calcium does, and calcium (in these soils) has been leached from the B horizon but occurs at higher concentrations in the underlying glacial till (C horizon). It is possible that the leaching of uranium from the A horizon and its adsorption on clay surfaces in the B horizon are important here.

In order to learn something about the absorption of radioelements on clay surfaces, a study of particle size was made. Clay, silt, and sand-size particles were separated by wet-sieving followed by sedimentation (the U.S. Department of Agriculture's mechanical analysis procedure was adapted for studying large samples). The gamma activities, in counts per minute per gram, were found to be as follows: clay, 6.95; silt, 5.40; sand, 1.38. The fact that the silt and clay activities are of the same order of magnitude would seem to indicate that a substantial portion of the radioelements are held in mineral form in the silt range. This is in agreement with the findings of Hoogteijling and Sizoo (*8*). Some adsorption of radioelements on clay surfaces may also occur.

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14 October 1959

Resetting the Sporulation Rhythm in Pilobolus with Short Light Flashes of High Intensity

Abstract. The "clock-controlled" endogenous sporulation rhythm in the fungus *Pilobolus sphaerosporus* has been investigated as part of a comparative study aimed at elucidating characteristic common features of circadian (*1*) rhythms. *Pilobolus* was chosen for inclusion in this study because of its demonstrated rhythm and sensitivity to light, and because it is a relatively simple plant. It has been shown that a single, high-intensity, 1/2000 second light flash will completely reset (shift the phase of) a rhythm persisting in continuous dim red light at constant temperature, and that one or more transient cycles occur before the phase shift is complete. The significance of these results is discussed.

The fungus *Pilobolus sphaerosporus* ejects spores at periodically timed intervals. The organism possesses an endogenous, temperature-compensated, rhythmic system which can be synchronized by appropriate light-dark cycles or temperature cycles but which persists with approximately a 24-hour period in continuous darkness or continuous dim red light (*2*). This "clock-controlled" sporulation rhythm is especially sensitive to light, and we have therefore examined the phase-shifting characteristics of the rhythm in response to light flashes of short duration and high intensity. This investigation (*3*) is part of a comparative study in which the general characteristics of the biological clocks of such diverse organisms as mammals (*4*), insects (*5*), and microorganisms (*6*) have been investigated.

From the comparative point of view it is desirable to know whether the properties of the "clock" system in microorganisms are qualitatively similar to those in higher organisms. As a tool for the comparative study, we have attached considerable significance to the way in which the phase of a persistent rhythm is shifted in response to single light stimuli (*7*). The fact that a new steady state is not achieved immediately, but only several cycles after a phase-shifting light signal, has been interpreted by us in terms of a generalized coupled-oscillator model. The transient approach to new phase is interpreted in terms of a gradual re-entrainment of one oscillator (not reset by the light signal) by another oscillator which is reset by the light signal. These transients, which may continue for seven or eight cycles in hamsters and three or four cycles in *Drosophila*, are difficult to detect in microorganisms and plants. The present demonstration of their occurrence in *Pilobolus*, together with the previous claim for their existence in *Euglena*, is evidence that the underlying features of the clock system which they reflect require neither the complexity of multicellular organization nor the presence of a nervous system.

Pilobolus sphaerosphorus was cultured on Bovung-oatmeal-agar of the following composition: 200 gm of Bovung (Walker-Gordon dried cow manure) boiled in 1 liter of water for 20 minutes and filtered through cheesecloth; 60 gm of oatmeal boiled 60 minutes in 1 liter of water and filtered through cheesecloth; 1.2 gm of K_2HPO_4; 1 gm of KH_2PO_4; and 40 gm of agar. The total volume was brought to 2 liters with water, and the medium was autoclaved for 20 minutes and poured into petri dishes 50 mm in diameter.

Agar-block transfers were made at 3- to 4-day intervals, and the plates were kept in a 25°C cabinet maintained on a light cycle with 12 hours of white fluorescent light per 24 hours. Sporulation started 6 or 7 days after inoculation. Ejected spores were collected with a specially constructed device consisting of a moving carriage holding eight petri plates which are slowly (56 mm/hr) pulled beneath eight glass strips just above the petri plates. The ejected spores adhere to the glass strips. Every 24 hours the glass strips were removed and replaced

with clean ones, and the carriage was reset for another 24-hour run. Ejected spores were counted against a grid calibrated in hourly intervals. The whole apparatus is in a room at 25°C in continuous dim red light.

Experiments were performed as follows: Plates were transferred from the light-cycle cabinet 6 or 7 days after inoculation to the carriage of the recording device. The transfer was performed at the very end of a dark period before the lights were turned on, and the carriage was set in motion at the time of the "expected dawn" when the lights would have been turned on. This time was considered to be hour zero of the cycle. At each of the hours 0, 3, 6, 9, 12, 15, 18, and 21 a plate was removed to a dark room, exposed to a single, high-intensity 1/2000 second flash from a stroboscopic lamp, and replaced in the carriage. The plates continue to eject spores for at least 4 days and in some cases for 5 or 6 days. In Fig. 1*C* the absence of data for some of the cultures on the 5th day reflects the fact that these particular cultures had ejected all of their spores in 4 days.

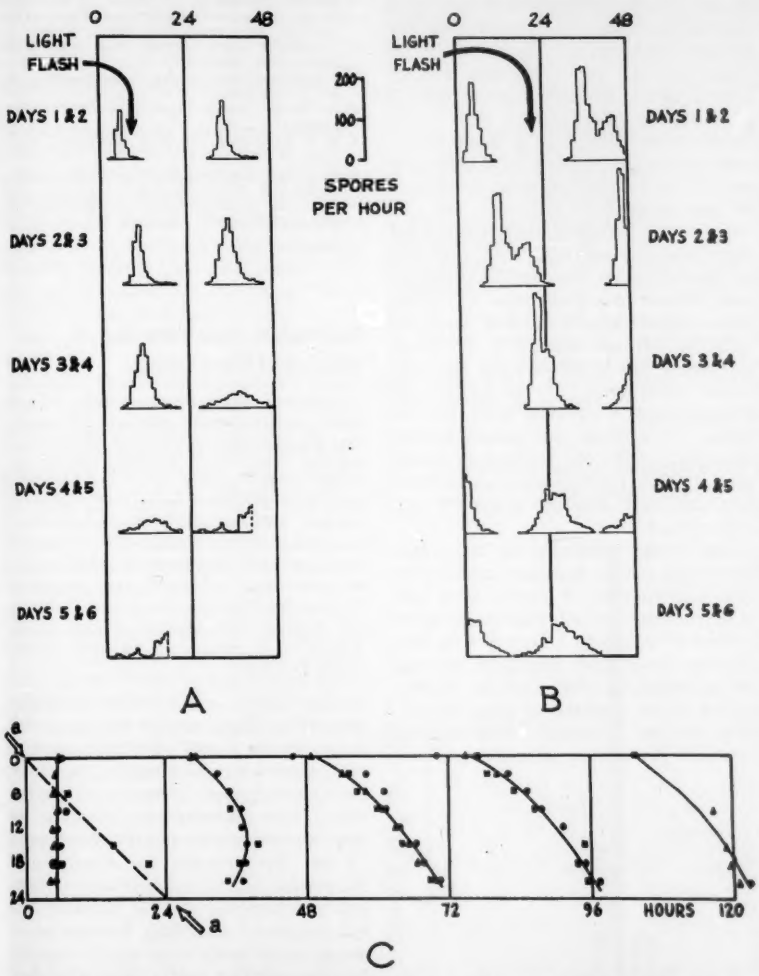

Fig. 1. *A*, *B*, Histograms of the number of spores discharged in hourly intervals from a petri plate culture of *Pilobolus sphaerosphorus*. Six days' record are shown with each day's record (except the first and last) being repeated once below, and once to the right of, the previous day's record. The sporulation rhythms of the cultures were previously synchronized by a light-dark cycle. At hour 0 of day 1 (24 hours after the last "dawn") the cultures were placed in continuous dim red light and constant temperature and remained in these conditions for the six days shown here. Nine hours (*A*) and 21 hours (*B*) after hour 0 (the "subjective dawn") a high-intensity, short-duration light flash was given to each culture. The histograms illustrate the way in which the rhythm controlling sporulation was reset in phase. *C*, Medians of the sporulation peaks of a number of similar experiments. The horizontal time scale (5 days) represents the number of hours elapsed after the cultures were transferred from the light cycle to constant dim red light. Hour zero is 24 hours after the last dawn of the previous light cycle. The dashed line *a-a* and the numbers on the vertical scale indicate the time in the cycle (measured from subjective dawn) at which each culture received a strobe flash. The circles, triangles, and squares correspond to replicate experiments.

Figure 1 summarizes the results of three replicate experiments of this type. Two histograms, corresponding to experiments in which the strobe flashes were given at hours 9 and 21, show the way in which the rhythm controlling sporulation was reset in phase. Part *C* of the figure, in which the medians of the sporulation peaks are shown, summarizes the results of all of these experiments. It may be pointed out that by the second or third day after the strobe flash the cultures had been almost completely reset—that is, the line through the medians of the peaks is essentially parallel to the line *a-a* which indicates the time at which the strobe signal was given. The reset is not immediate, however, as might be expected from some of the simplest oscillatory schemes which could be visualized as models for the system. There is a gradual approach to new phase involving one or, in some cases, more transient cycles.

This combination of transients with ultimate determination of phase by a single signal is what we reported earlier for *Drosophila*. It is what led to the coupled-oscillator scheme we described (*7*). In the previously reported experiments with *Drosophila* the duration of the light signal was either 12 hours or 4 hours, and the pattern of transients in the *Drosophila* experiments cannot be compared with the pattern of transients in the present experiments. Unpublished experiments with *Drosophila*, in which a strobe light was used to reset the eclosion rhythm, indicate that the details of the pattern of transients are not the same in the two organisms. The phase of the rhythm in *Drosophila* can be shifted only a few hours at the most, and both short-period ("advancing") and long-period ("delaying") transients are observed. In *Pilobolus*, on the other hand, large phase shifts are observed and only long-period ("delaying") transients are observed. A more detailed analysis of the *Pilobolus* system might reveal the existence of "advancing" transients when strobe signals are given in the vicinity of hours 0 and 24. In any event, this constitutes a detail of the system and the essential point which is demonstrated by the *Pilobolus* experiments is the indication that light operates on an oscillatory system distinct from that which proximally regulates spore-ejection time.

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1. The term *circadian*, which was introduced by F. Halberg, includes all persistent endogenous biological rhythms with periods of about 24 hours. It is introduced in preference to the somewhat confusing terms *diurnal rhythm, daily rhythm, 24-hour rhythm*, and others.
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2 November 1959

The Error Hypothesis of Mutation

Abstract. Accumulation of mutants in glucose-limited chemostats is proportional to growth rate, while in tryptophan-limited chemostats it is independent of growth rate. This behavior, which implies the failure of the error hypothesis, may be explainable on the basis of a unitary hypothesis: the results with glucose may be due to reversion or loss of latent mutants.

The most common hypothesis of gene mutation has been the error hypothesis, which assumes that mutations arise as a result of an "error" in gene replication [that is, the "copying error" (*1*)]. According to this hypothesis, rate of mutation would be expected to be proportional to rate of gene replication, which in turn is proportional to division rate under constant growth conditions. However, Novick and Szilard (*2*) demonstrated that the rate of spontaneous mutation to resistance to bacteriophage T5 was independent of growth rate in tryptophan-limited chemostat cultures of *Escherichia coli* strain B/1, *t* for generation times varying from 2 to 12 hours. Their result appeared to be contradictory to the error hypothesis of mutation, suggesting that the rate of gene replication might be independent of the growth rate of the cell.

In contrast to the above response, when growth is limited with glucose the rate of accumulation of mutants is proportional to growth rate (Fig. 1) for caffeine-induced mutations in the same strain and in the related strain B. These contrasting results would be easily understood if the process of spontaneous mutation were different from that for caffeine-induced mutation. Instead, evidence supports their similarity: work in this laboratory (*3*) indicates that the rate of accumulation of caffeine-induced mutants also is independent of growth rate in tryptophan-limited cultures. Furthermore, the rates of both spontaneous and caffeine-induced mutations decrease in the presence of the antimutagen guanosine, although not to the same extent (*4*).

It is possible to regard these divergent responses in glucose- and tryptophan-limited cultures as arising in a common manner by assuming that the results with glucose-limited growth are due to a secondary process. In this unitary hypothesis, the first step is the induction of the latent mutant, a cell with wild phenotype which will later exhibit the mutant character in itself or in its progeny. The induction rate is presumed to be relatively independent of growth rate. The second step is the transition of the cell from latent to expressed mutant. During this transition or prior to it, some latent mutants may be lost by death or reversion. In glucose-limited cultures the fraction of latent mutants surviving this transition is, according to the data of Fig. 1, proportional to growth rate; in tryptophan-limited cultures the loss would be constant, perhaps negligible. Evidence supporting this hypothesis has been obtained from study of the kinetics of accumulation of mutants upon the addition of caffeine to glucose-limited chemostats (*5*): the fraction of latent mutants that reach phenotypic expression appears to diminish as growth rate is decreased.

The major difficulty of the error hypothesis is that it cannot explain the time-independence of the mutation rate in tryptophan-limited cultures without further assumptions. This is true also of other hypotheses which are dependent on metabolic rate, such as "errors" arising in the synthesis of genic precursors, or the enzymatic inhibition of these. If the unitary hypothesis is correct, then mutation must result from a rate-independent process, as, for example, a rare alteration or substitution in already-formed genetic material due to a process which is relatively independent of metabolic rate (*6*).

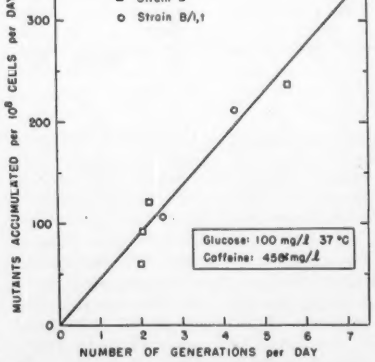

Fig. 1. Proportionality between growth rate and rate of accumulation of mutants to T5 resistance in glucose-limited chemostat cultures.

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2 November 1959

Cytological Instability in Tumors of Picea glauca

Abstract. Smear preparations of cells taken from primary explants of normal and adjacent tumor wood of *Picea glauca* showed completely regular mitotic behavior in the normal cells, with the great majority of cells diploid (22 chromosomes), a few tetraploid, but almost none aneuploid. Tumor tissue was extremely unstable, with numbers ranging from 3 to more than 70, with a high proportion of aneuploids but otherwise normal-appearing mitoses. The relation of this mitotic instability to other data on these tumors is pointed out.

Picea glauca and its western equivalent, *Picea sitchensis*, in certain limited areas on the coasts of North America and in a few inland locations, is subject to a massive type of tumorous growth which has occupied the attention of this laboratory for a number of years (*1–3*). The growths are distinguished from most "burls" by their smooth, subglobose character (*4*). No causal organism has been identified. Tumors occur singly or in great numbers on trunks, branches, and roots (*5*). In section they always extend to the pith, indicating that they originate in the bud (*2*). Apparently single cells in the procambium or primary vascular cambium undergo some profound and irreversible change, giving rise to single files of tumor cells which subsequently expand to form chimeric sectors of tumor wood (*2, 5*). Such transformations are frequently multiple in a particular bud, the resulting adjacent sectors fusing to produce the massive growths observed.

We have concentrated much of our attention on defining the physiology of

tumor tissues as contrasted with the normal. One possible origin of physiological instability is to be sought in the mitotic behavior. Rapid-growing, friable tissue cultures are well adapted to investigation of mitoses by squash methods. We have initiated such studies, using a modified Feulgen method followed by Belling's acetocarmine. We have used newly formed cells arising on primary explants grown for 1 to 2 months in culture. Tumor wood and normal wood for initiation of cultures was taken from adjacent areas on the same tree; several affected trees were used. This report presents the results of a cytological study of 1000 somatic nuclei from dividing callus cells. Three hundred and twenty were from cultures of normal wood, 680 from tumor wood.

The diploid chromosome number for most conifers (*Cupressus, Juniperus, Metasequoia, Sequoia, Taxodium, Torreya*) is given by Delay (*6*) as 22 or a multiple thereof (44, 66). Seitz (*7*) and Sax (*8*) give 24 ($= 2 \times 12$) for several species of *Picea*.

The chromosomes are long and slender, making counts difficult. (Fig. 1, *A,B,C*). Of the normal cells of *Picea glauca* examined, 51 percent clearly had 22 chromosomes (Fig. 1*B*, Fig. 2) and an additional 15 percent were close enough to this number to be within the range of probable counting errors. Another 5 to 8 percent were clearly tetraploids with 44 chromosomes. This proportion of tetraploids is not unusual in many normal tissues. Only a very small percentage appeared to be aneuploids, and these counts might have been due to errors. The mitotic figures were regular, without lagging chromosomes or bridges (Fig. 1*D*). No pycnotic nuclei were observed. The cultures from normal wood thus appear to be made up of cells which are essentially uniform and regular in their behavior. We are justified in drawing conclusions from a relatively small number of such cells.

The behavior of the tumor cultures was different. While no pycnotic nuclei were observed and while there was no evidence of bridges, there was nevertheless a very high percentage of mitoses which were aneuploid. Gymnosperm cells, even in the meristematic state, have a tough pellicle and are thus not subject to the tearing which in more fragile materials permits the loss of chromosomes and renders counts suspect. Mitoses which seemed to be intact gave numbers ranging from as low as *three* recognizable chromosomes to uncountable complexes of more than 70. The chromosomes appear to be somewhat thicker than in normal wood, although in the absence of precise measurements this impression remains sub-

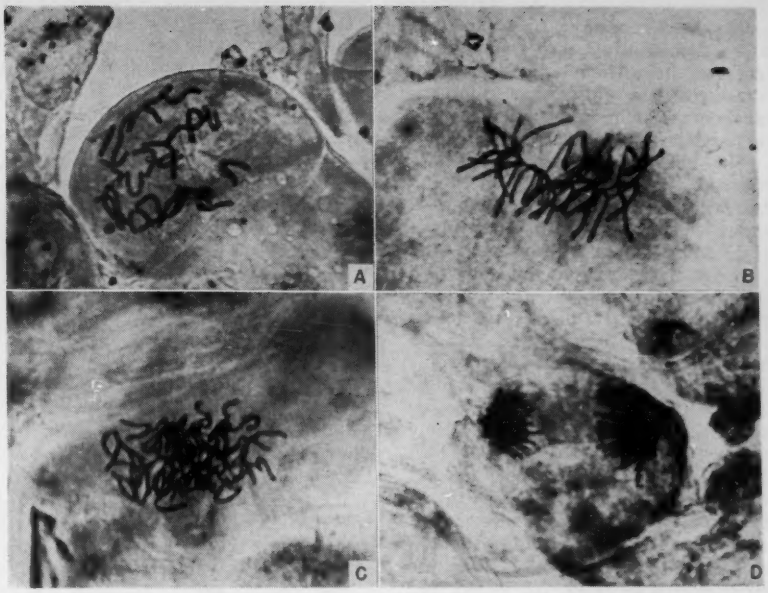

Fig. 1. Mitoses in cells of primary tissue cultures from *Picea glauca* (about ×200). *A*, Diploid metaphase, 22 chromosomes (tumor). *B*, Early anaphase, two sets of 22 chromosomes (normal). *C*, Metaphase, tetraploid, 44 chromosomes (tumor). *D*, Telophase (normal); note the completely regular grouping, and the absence of lagging chromosomes or bridges.

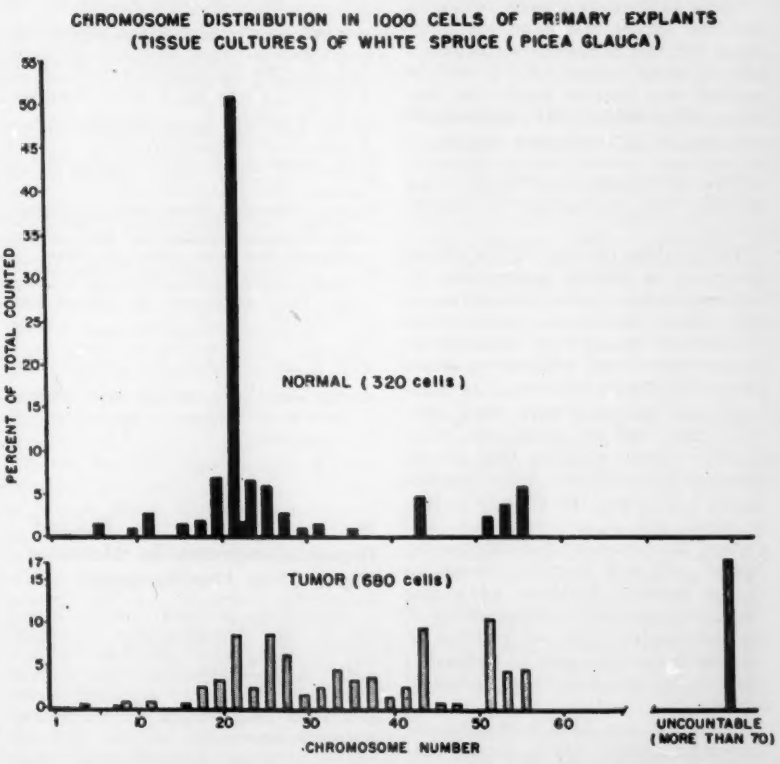

Fig. 2. Chromosome distribution in 1000 cells of primary explants (tissue cultures). Histogram of normal cells (top) with modes at 22, 44, and 56 (probably 55), compared to tumor cells (bottom) with major modes at 22, 26, 44, and 52 and minor modes at 28, 34, 54, and 56 chromosomes.

jective. While tumor cells do not appear to be significantly larger than normal, nor more irregular in size, the preparations give the impression of many *more* mitoses in tumor cultures than in normal.

The difference in mitotic behavior between normal cells and adjacent tumor cells is certainly marked. Figure 2 shows that in normal tissue the modes at 22 (diploid) and 44 (tetraploid) are clear-cut. The same modes reappear in the tumor tissue, but there are additional modes at 26 and 52 and minor concentrations at 28, 34, 54, and 56. Statistical analysis of our data by the usual *t*-test shows that the differences between the two sets are certainly significant at the 95:5 level and probably so at 99:1 (*9*). The modes mentioned are all real since they reappear whether we plot the 680 tumor nuclei as a group or divide them chronologically, according to dates of counting, into two groups of 349 and 331, respectively. Even the minor variations at 18, 20, 34, 36, and 38 fall outside the band of statistical uncertainty. The extreme cytological instability of tumor wood as contrasted to the high degree of uniformity in adjacent normal tissue emerges from this study with great clarity.

These findings are entirely consonant with our earlier results on the nutritional behavior of normal versus tumor cells in tissue culture (*3*). It will be recalled that normal wood was consistent in its behavior on a given nutrient while tumor wood was variable in growth rate, growth pattern, degree of solidity or friability, and color, often throwing irregular sectors in a single culture.

The variable cytology of the spruce tumors is in marked contrast to the stable cytology of the best known of other plant tumors, the "crown gall." Levine (*10*) found both chromosome number and mitotic behavior in crown gall to be quite normal. Although tetraploids and octoploids were fairly common, there was no aneuploidy, polyploidy evidently resulting from simple failure of cell division to follow mitosis. Kupila (*11*) found the same to be true of crown gall of sunflower, pea, and tomato. She concluded that only normal diploid cells took part in propagation of the tumors. Partanen (*12*) also found, by photometric measurements of deoxyribonucleic acid, no evidence of aneuploidy in crown gall of *Helianthus* and even less polyploidy than in normal tissues.

The results also differ from those described by Torrey (*13*) in normal pea-root cultures in which there appears to be a progressive polyploidy with selection of the tetraploids on certain culture media, but again without aneuploidy.

The cytology of these tumors most closely resembles the later stages noted by Partanen in cultures of fern gametophyte tissue (*14*) and by Hauschka (*15*) and others in animal tissue cultures and ascites tumors. These authors have noted a gradual loss of euploidy, that is, a spreading of chromosome number with time. This deviation they have attributed to the "abnormal" conditions involved in growth in vitro and in the ascites form, to the removal of the selective mechanisms which tend to eliminate those deviations which may occur in the body. This explanation can scarcely apply to spruce callus maintained for only brief periods as primary explants and in which normal and tumor tissues grown under identical conditions behave so differently.

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30 October 1959

Radiometric Analysis of Tritiated Organic Compounds by Means of Vapor Phase Chromatography

Abstract. An analytical method, involving the gas chromatographic separation and the quantitative measurement of tritiated volatile compounds, was studied. The method has been successfully employed to detect traces of carrier-free tritiated substances.

Identification of trace constituents in a mixture of radioactive compounds and the measurement of their radioactivity has become increasingly important in the preparation and application of labeled substances. Volatile compounds can be efficiently fractionated by means of vapor phase chromatography, and the radioactivity can be determined in the effluent gas.

This method has the basic advantage of detecting all the radioactive components of the mixture to be analyzed, and hence constitutes a powerful means for the separation and dosage of carrier-free compounds.

In the case of tritium-labeled substances, the low energy of β-particles precludes the use of Geiger counters or scintillation heads immersed in the effluent gas, which have been employed, for example, in the dosage of volatile compounds containing Br^{80} and Br^{82} (*1*), or thin-walled Geiger counters, useful in the case of C^{14}-labeled substances (*2*). The continuous condensation of emergent vapors in a cooled solution of organic scintillator, satisfactory for C^{14} (*3*), would result in low efficiency and high background in the use of tritiated compounds. In view of these drawbacks, efficient use can be made only of proportional counters (*4*) and ionization chambers (*5*, *6*). This paper describes a technique, based on the use of a flow ionization chamber, suitable for the separation and determination of the radioactivity of tritiated compounds having boiling points up to 150°C.

The purpose of the present investigation was to develop a technique for the measurement of radioactivity, independent, within a wide range, of the particular gas chromatographic conditions such as the flow rate of the carrier gas, the column temperature, the nature and the amount of the compounds to be analyzed, and so forth.

According to this technique, the effluent gases from the chromatographic column, having been passed through a conventional thermoconductivity cell for the usual analysis of compounds present in macroscopic quantities, are diluted with a current of the carrier gas in an appropriate mixer. The dilution is effected in such a way that the total flow rate may be adjusted to a certain fixed value at which the ionization chamber is calibrated. The radioactivity measurements are consequently independent of the carrier gas flow rate in the chromatograph. Besides, the relatively large volume of the gas in which the vapors leaving the column are diluted eliminates the necessity of heating the ionization chamber, which is generally required at low flow rates in order to prevent the condensation of compounds with high boiling points. Substances such as chlorobenzene and anisol (boiling points 132° and 155°C, respectively) have been, in fact, satisfactorily analyzed. The possibility of maintaining the cham-

ber at room temperature offers remarkable advantages, as the radioactivity measurements remain unaffected by operating the chromatograph at different temperatures.

The sensitivity of such a continuous radioactivity measurement device is proportional to the ratio between the chamber volume and the gas flow rate. However, the volume of the ionization chamber is conditioned by the need (among others) to obtain a reasonable resolution of the elution peaks, comparable to that of the thermoconductivity cell in the chromatograph (in our case a Fractovap model B, Società C. Erba). A satisfactory compromise was attained by using a 100-ml ionization chamber calibrated at (total) carrier gas flow rate of 10 lit./hr. To avoid the eddying and mixing of the gases in the ionization chamber, the inlet tube is connected to the top center of the cylindrical chamber body by means of a joint of gradually increasing diameter, thus reducing the speed and eliminating the turbulence of the gas current. The stainless steel chamber may be easily dismantled for decontamination without affecting its calibration. It is mounted on a vibrating reed electrometer (model 31, Applied Physics Corp.) connected to a potentiometric recorder synchronized with that of the Fractovap. When one applies the measuring technique involving the current leakage through a calibrated high resistance, with a 10^{13}-ohm resistor and an input capacity of about 10^{-11} farad, the responses of the electrometer are adequately fast, 63 percent being within 1 second and 85 percent within 2 seconds (*6*). On leaving the ionization chamber, the gas is made to pass through a system of traps cooled with liquid nitrogen, in order that radioactive fractions may be recovered separately. The apparatus is diagrammed in Fig. 1.

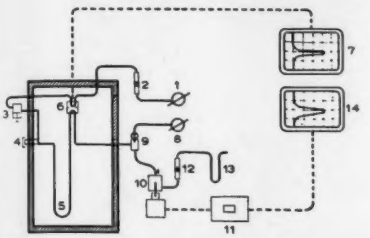

Fig. 1. Apparatus used in the study. (1) Gas inlet regulating valve; (2) carrier gas flowmeter; (3) gaseous samples introduction device; (4) liquid samples introduction device; (5) column; (6) thermoconductivity cell; (7) thermoconductivity cell recorder; (8) dilution gas regulating valve; (9) mixer; (10) ionization chamber; (11) electrometer; (12) chamber flowmeter; (13) liquid nitrogen trap system; (14) electrometer recorder.

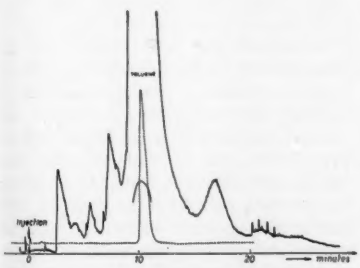

Fig. 2. Analysis of tritiated toluene. Column: polyethylene glycole 400 on celite, length 1 m, internal diameter 4 mm; temperature: 105°C; carrier gas nitrogen; flow rate 1.5 lit./hr in the column, 10 lit./hr in the ionization chamber.

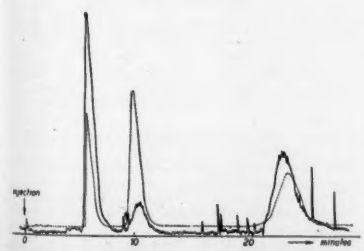

Fig. 3. Analysis of a mixture of benzene, toluene, and chlorobenzene. Conditions were the same as in Fig. 2.

A typical analysis of tritiated toluene, labeled by the Wilzbach method (*7*), is shown in Fig. 2. The dotted tracing refers to the thermoconductivity output; the solid tracing, to the electrometer response. An interesting feature of this analysis is the absence of impurities detectable by means of gas thermoconductivity, while an appreciable percentage of the total radioactivity is given by carrier-free compounds other than toluene, probably by partially hydrogenated benzene and toluene (*8*), as shown in the electrometer tracing. In Fig. 3 is reported the analysis of a mixture of tritiated benzene, toluene, and chlorobenzene, previously purified by means of vapor phase chromatography and hence free of radioactive impurities. The sensitivity of the apparatus employed allows the detection of tritiated compounds having a minimum activity of some mμc, and the measurement of activities of about 20 mμc. Quantitative analyses have been carried out with the use of weighed quantities of compounds having known specific activity. The standard samples have been analyzed under very different operating conditions in the chromatograph: temperature ranging from 70° to 135°C, flow rate from 0.5 to 3.5 lit./hr, and sample size from 0.1 to 10 mg. The calibration has been found to be constant within 2.4 percent.

The method of analysis described here can be extended, without any modification, to volatile organic compounds labeled with other weak β-emitters, as C^{14} and S^{35} (*9*).

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19 October 1959

Morphologic Observations on Trachoma Virus in Cell Cultures

Abstract. When cultures of cells derived from the entoderm of the chick embryo were infected with trachoma virus, cytoplasmic inclusion bodies composed of viral particles were easily demonstrated. The inclusions are similar to those found in stained smears from trachomatous eyes and they developed in a sequence characteristic for this group of viruses. This method of culture appears to offer a valuable additional tool for study of the trachoma agent.

Several recent isolations and successful serial passages of morphologically typical trachoma virus in embryonated eggs (*1*) have for the first time provided a constant source of this virus for detailed examination in the laboratory. This report describes the use of a cell-culture system in which growth of a trachoma virus isolate readily occurs, as indicated by formation of typical inclusion bodies. To our knowledge, no previous report of successful culture of the trachoma virus in vitro has appeared.

The virus used represented the 10th and 11th yolk sac passages of strain No. TW10, obtained from a case of trachoma and isolated in the laboratory of J. Thomas Grayston at the Naval Medical Research Unit No. 2, Taipei,

Taiwan. It was supplied to us by Grayston as a lyophilized preparation of the 5th yolk sac passage.

For inoculation of tissue cultures the virus was partially purified by a procedure adapted from methods found useful for rickettsias (*2*) and for psittacosis virus. It consists of trypsinization of a heavy emulsion of infected yolk sacs, concentration of virus and separation from lipids by high-speed centrifugation, and further removal of extraneous materials by low-speed centrifugation after resuspension in medium containing bovine albumin (0.6 percent by volume) and celite (10 percent of the weight of the original yolk sacs).

The tissue cultures were prepared by a method originally used for culture of feline pneumonitis and mouse pneumonitis viruses (*3*) and since found suitable for culture of other viruses of the psittacosis group and for rickettsias (*4*). The method consists of explanting the entodermal layer of 4-day chick embryos to cover slips and incubating at 36°C under a medium composed of Hanks' balanced salt solution, 75 percent, and chicken serum, 25 percent, without antibiotics. A monolayer of large epithelial cells develops within a few days. Previous investigations in this laboratory (*5*) have shown that psittacosis virus, as well as *Rickettsia prowazeki*, can be detected in much higher dilutions in these cultures if the viral particles are centrifuged onto the cell layer.

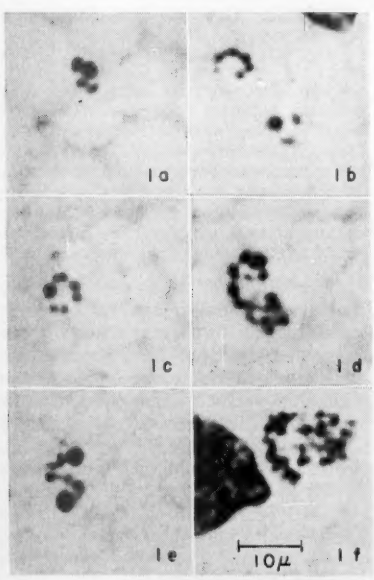

Fig. 1. Virus of trachoma cultivated in entodermal cells of chick embryo. (*a–d*) Initial bodies 18 hours after inoculation, showing compact groups and ring arrangement. (*e*) Plaques and smaller forms at 24 hours. (*f*) Cluster of viral particles at 30 hours. (× 1950)

For this purpose the explants were placed on circular cover slips 12 mm in diameter and incubated in flat-bottomed culture tubes under 0.5 ml of the medium described above. On the 6th or 7th day the fluid was replaced by fresh medium containing 5 percent of virus preparation of the desired dilution. The infected tubes, as well as uninoculated control tubes, were then centrifuged in the horizontal position at 3000 rev/min for 1 hour in a refrigerated centrifuge at 20°C. The fluid was again replaced with fresh medium, and the tubes were returned to the incubator. At selected intervals the medium was removed from groups of tubes and the explants were washed with balanced salt solution, fixed with methyl alcohol, and stained by the May-Grünwald-Giemsa method.

Intracytoplasmic viral inclusion bodies were recognized in preparations fixed as early as 18 hours after inoculation and were seen in varying stages of development through a 72-hour interval. The structures observed were similar to those found in direct smears from patients and were characteristic of this group of viruses (Figs. 1 and 2). The figure legends provide brief descriptions of the morphologic types seen. It is clear that this virus goes through a developmental cycle similar to that of related viruses such as psittacosis and lymphogranuloma venereum.

The maturing inclusions possess a considerable degree of rigidity, as indicated by the rarity of instances of departure from the usual circular or oval outline. The inclusions are often seen to distort the nucleus (Figs. 1*f* and 2*a*) and in turn are only slightly modified by it. In this regard trachoma virus resembles mouse pneumonitis virus cultured in entodermal cells (*3*). By contrast, the virus is very different in appearance from the viruses of feline pneumonitis (*3*) and psittacosis (*6*). In the latter cases the inclusion bodies are quite irregular in shape, occupying space between and around cytoplasmic vacuoles.

Although many cells infected with trachoma virus are seen in satisfactory preparations, the over-all incidence of such cells is low, and no appreciable destruction of the cell culture occurs. In fact, individual cells appear to be little affected by the presence of an inclusion body, at least before the final stages of viral development. There was little or no evidence for a second cycle of viral growth in these cultures, even when they were recentrifuged at times when infective elementary bodies were expected to be present in the fluid. However, the infectivity of the cultures was demonstrated by passage of either culture fluid or trypsinized cells to the yolk sac of embryonated eggs.

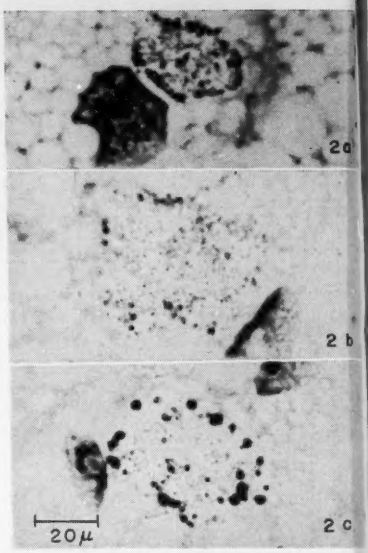

Fig. 2. Virus of trachoma cultivated in entodermal cells of chick embryo. (*a*) Vesicle, at 48 hours. (*b*) Vesicle, at 60 hours, containing numerous elementary bodies. (*c*) Vesicle, at 60 hours, containing elementary bodies and plaques. (× 980)

Although our first studies by this method of culture dealt principally with morphology, we can predict, by analogy with other similar viruses, that this technique will be of value for other types of study as well. Among these are quantitation by means of an infected cell count, as performed with feline pneumonitis virus (*3*), and observations on drug susceptibility as reported with psittacosis virus (*6*).

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3 November 1959

Calcium and Electric Potential across the Clam Mantle

Abstract. An excised clam mantle develops a potential difference, shell side positive, when both surfaces are bathed by tap water or physiological saline solution. The magnitude and sign of the potential are sensitive to the calcium concentration in the bath solution. Bubbling carbon dioxide through the solution bathing the shell side increased the potential.

It was reported some years ago that the mantle of several fresh-water lamellibranchs developed a potential difference between the two faces when the preparation was bathed with tap water (*1*). More recent work has shown that transepithelial potentials are generated as a concomitant of the active transport of ions—sodium transport in the case of the frog skin and toad bladder and chloride movement across the vertebrate gastric mucosa (*2*). The mantle in certain mollusks has been implicated in the mobilization of calcium for shell formation (*3*), and it seemed that this ion might be related to the potential difference described by Lund. Such a relationship would be important for at least two reasons. It would afford a new preparation for studying the means by which bioelectric phenomena are developed. More important, perhaps, it would provide a system for studying the movement of calcium by living membranes. Since the preparation seems to be virtually unknown, we wish to direct attention to it here by reporting some experiments that show that the potential difference is dependent on the calcium ion content of the medium.

When a mantle is excised and mounted so that it separates two chambers containing bathing solutions, a potential difference can be measured across the epithelium. The shell side is positive to the body side, and the magnitude is of the same order of size as potentials reported for a variety of epithelia (that is, 30 to 70 mv). The potential falls more or less rapidly, but not to zero, so that after 1 to 2 hours a small, stable potential is generated, usually 2 to 10 mv, with the shell side of the preparation positive. Although this is less striking than the initial potential difference, its stability made it more useful as an experimental variable, and the experiments reported below concern this quantity.

The gross composition of the bathing solutions does not seem to change the electrical picture qualitatively. Lund used tap water on both sides of the mantle, while we have used a clam Ringer's solution and occasionally a sodium-free "choline Ringer's"; in all cases an initial potential difference was developed which decreased toward a final, stable value. However, the stable potential difference was exceedingly sensitive to calcium ion concentration in the bathing solution. Figure 1 shows how this potential difference varied as a function of calcium in the body-side solution. Neither sodium nor potassium affected it in this fashion. It is important to note that the concentration in the other (shell-side) solution also caused the potential difference to change, in this case to decrease as a function of concentration and even to reverse polarity.

The data also show, however, that the mantle does not act simply as a calcium electrode, for the potential difference changed less than the theoretical 29 mv per tenfold change in concentration.

One other interesting phenomenon is the change in potential difference brought about by bubbling CO_2 through the shell-side solution. Incorporation of 5 percent of CO_2 in the oxygen used to aerate caused a marked increase in the magnitude of the potential difference. Bubbling the gas through the body-side solution had no effect. The presence of carbonic anhydrase in the oyster mantle was reported by Wilbur and Jodrey (*4*), and carbonic anhydrase is also present in the clam mantle (*5*). Its role in the CO_2 effect has not been assessed.

The possible participation of calcium in the genesis of the potential difference was suggested by the fact that the mantle (at least in the oyster) transports calcium from body to shell side, as shown by the excellent work of Wilbur's group. Exploration for a CO_2 effect was suggested by the fact that carbonate is required for shell formation. However, the exact role of these substances in the bioelectric phenomenon and the way they are handled by the mantle are still unknown (*6*).

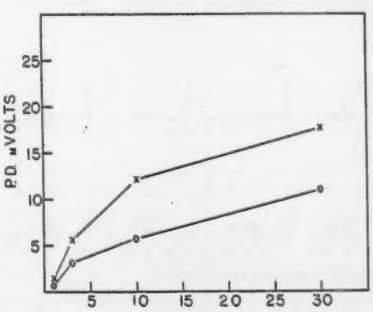

Fig. 1. Mantle potential (in millivolts) as a function of calcium concentration. The mantle was excised and equilibrated in a physiological saline containing $CaCl_2$ (1 mmole/liter). After 4 hours it was mounted in the experimental chamber with the same saline bathing both surfaces. Changes in calcium concentration were made by replacing aliquots of the saline with a volume of stock $CaCl_2$ solution sufficient to maintain isotonicity. The results of two different experiments are shown.

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29 October 1959

Delayed Effects of Nicotine on Timing Behavior in the Rat

Abstract. Hungry rats were trained to time precisely by rewarding with food those lever responses spaced 20 to 22 seconds apart. Injections of nicotine disrupted the timing behavior slightly, but pronounced delayed effects occurred 3 and 4 days after the drug injection and following a temporary return to base-line performance.

Research in psychopharmacology has largely taken the direction of determining the immediate effects of drug administration on behavior. Latent or delayed actions upon behavior have not been extensively investigated. Because of this, it frequently has been assumed that recovery of base-line performance following a drug injection indicates that the action has been dissipated and that subsequent dosing may be safely undertaken. The errors inherent in such a procedure are illustrated by the findings of the present investigation, which demonstrate clear-cut behavioral effects of nicotine several days after injection and following a temporary return to base-line behavior.

The behavior under investigation involved a precise timing discrimination (*1*). Hungry rats were first trained to space their lever-pressing responses at least 20 seconds but no more than 40 seconds apart in order to obtain a drop of sweetened, condensed milk. The 20-second period of eligibility (20-second limited hold) after the 20-second timing period had elapsed was progressively reduced over many weeks of training until a 2-second limited hold was in force. The final experimental conditions for assessing the effects of the drug

required that responses be spaced at intervals of 20 to 22 seconds in order to produce reinforcement. Responses which occurred either before or after the 2-second "pay-off" period were not reinforced, and merely initiated a new timing cycle.

Three male albino rats that had been feeding ad libitum were gradually starved to 80 percent of their original body weights, and were then maintained at the reduced weights by limited feedings immediately after each experimental session (*2*). The animals were trained in sound-resistant chambers containing a lever in one wall and an automatic feeding device that presented the 0.1-ml liquid reward for 4 seconds. All experimental sessions were of 2 hours' duration.

The timing behavior in this situation is conventionally described by a distribution that gives the relative frequencies of the times between successive responses (interresponse times). For this study the interresponse times were grouped into 2-second categories and cumulated over the 2-hour sessions. In addition, records were taken of the average daily response rate and the total number of reinforcements earned.

With sufficient training, the timing behavior sharpens so that a clear-cut peak in the interresponse time distribution occurs at the reinforced interval, or, for many animals, at the interval just preceding the reinforced one. A series of nicotine bitartrate injections, administered no more frequently than once a week, was initiated when the interresponse time distributions had stabilized and the total number of reinforcements obtained in each session was roughly constant.

Table 1. Total number of reinforcements obtained in the daily sessions indicated for four nicotine test series.

Drug dose* (mg/kg)	Number of reinforcements			
	Pre-drug	Day of drug injection	Day 1 post-drug	Day 4† post-drug
		Rat C-15		
0.1	59	50	65	36
0.15	40	40	53	14
0.25	47	40	62	25†
0.2	39	39	55	39
		Rat C-27		
0.1	60	39	72	29
0.15	56	26	68	26
0.25	48	61	57	32†
0.2	71	39	38	30
		Rat C-29		
0.2	81	23	81	38
0.15	64	78	72	55
0.25	54	61	65	46†
0.1	69	59	73	55
Grand mean	57.3	46.2	63.4	35.4
Predrug (%)	100	81	110	61

* Doses are listed in chronological sequence. † Values are number of reinforcements on day 3, rather than day 4, postdrug.

Figure 1*a* presents the interresponse time distributions for the series of experimental sessions preceding and following the largest dose of nicotine given. Examples of the base-line performance may be seen in the predrug histograms. The large proportion of interresponse times in the 0- to 2-second category is typical, and represents, for the most part, multiple bursts of responses, but the remainder of the distribution gives a good picture of the timing behavior. The distributions may be seen to peak at, or just prior to, the rewarded interval (white column), and to decline sharply at either side.

The crosshatched distributions were obtained on the day that the drug was administered; these distributions differed in no significant way from those obtained on the previous day, suggesting that the drug in this dosage has little or no effect on the timing behavior (*3*). For the two sessions following the drug day the timing behavior remained intact and perhaps even improved as indicated by an increase in the total number of reinforcements obtained (Fig. 1*c*). On the third day, however, the delayed effect occurred. This effect revealed itself as a flattening of the interresponse time distributions, an increase in the average response rate (Fig. 1*b*), and a marked decrease in the total number of reinforcements obtained (Fig. 1*c*). At this time the animals were observed to be somewhat agitated in the experimental chamber, but not in the home cages. No such agitation was observed on the day of the drug injection.

The reproducibility of the delayed nicotine effect is shown by the data presented in Table 1; the total number of reinforcements earned is used as an index of timing performance. In nearly every series the frequency of reinforcement on day 4 (or day 3) postdrug is seen to be depressed well below (on the average, 40 percent) the levels obtaining before or shortly after the injection. It also may be observed that the delayed effect (as well as the direct effect) of the drug tends to decrease with repeated dosing. Finally, it should be pointed out that the behavioral base line is a critical determinant of the drug effect, and particularly, in the present situation, it may be that a less stringent timing requirement might not reveal a similar magnitude of action.

Long-term biochemical changes have been described which result from single small doses of nicotine, and some of these may be related to the present behavioral findings (*4*). The changes reported in blood glucose levels, epinephrine output, and blood plasma potassium levels would appear to deserve further correlational investigation (*5*).

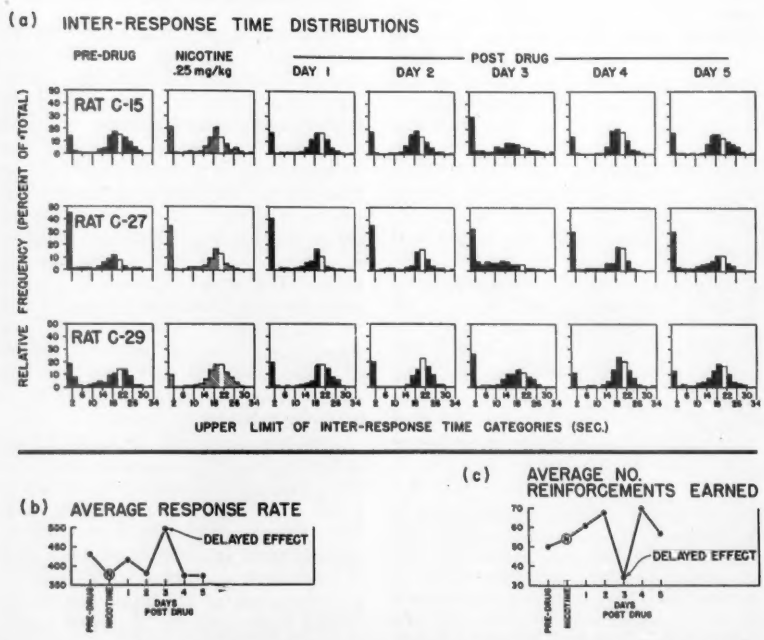

Fig. 1. Immediate and delayed effects of nicotine on three measures of timing behavior. (*a*) Individual relative frequency distributions of interresponse times for each day in the series. The white columns indicate the reinforcement interval. (*b*) Daily response rates averaged for three animals throughout the series. (*c*) Daily number of reinforcements earned, averaged for three animals throughout the series.

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2. A fourth rat died on the second day following the first nicotine injection.
3. Since the graphed data represent a third cycle in the experiment, the rats may have acquired a tolerance for the drug and therefore show little if any immediate nicotine effects.
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5. The authors wish to express gratitude to Larry Stein for his critical reading of the paper.

1 October 1959

Autoradiographic Investigation of Incorporation of H^3-Thymidine into Cells of the Rat and Mouse

Abstract. The application of H^3-thymidine results in labeling of those nuclei of cells in which deoxyribonucleic acid (DNA) is synthesized during the interval between application and the sacrifice of the animal (*1–3*). This paper reports autoradiographic investigation with H^3-thymidine of rats and mice. This method permits a more exact statement of the number of dividing cells than does the microscopic estimate of mitosis. The latter method is practically impossible in tissues with small fusiform cells. Moreover, it is possible to obtain information about the relative time of DNA synthesis in different cells.

Adult rats and mice received 460 and 50 μc, respectively, of H^3-thymidine by intraperitoneal injection, and were sacrificed after 90 and 60 minutes, respectively. Autoradiograms were prepared from 5-μ, paraffine-imbedded slices, by use of the stripping-film method (Kodak autoradiographic plates AR 10), or with liquid emulsion (Ilford G 5). Exposure times were up to 20 days.

The autoradiographic blackening was exclusively limited to a certain percentage of nuclei and matched the distribution of the chromatin in the nuclei. Nucleoli with a diameter above 2 μ appeared as white spots within the silver grain covered chromatin. A remarkable result was that the nuclei either were labeled rather uniformly or were absolutely free from silver grains. For that reason the percentage of labeled nuclei in a section was independent of the exposure time.

The relative numbers of labeled nuclei (H^3 index) and of mitosis (mitosis index) were determined for different tissues and the percentages these formed of the total number of examined nuclei were calculated. Table 1 gives the results.

The examined tissues can be classified in three groups with a distinct difference in the percentage of H^3-labeled nuclei. These three groups correspond to the scheme given by Cowdry (*4*).

Fixed postmitotic cells (central nervous system, musculature). No labeled nuclei are found in ganglionic cells, in cells of striated muscle, or in cells of the heart muscle. However, in all three tissues there are some mesenchyme cells with labeled nuclei. Likewise, some labeled nuclei were found in the choroid plexus and in cells of the subependymal regions of the brain. Contrary to the case of striated muscle, there are few labeled nuclei in the cells of smooth muscle.

Reversible postmitotic cells (parenchymatous organs). In the liver the distribution of labeled nuclei does not favor certain lobes nor parts of lobules. Liver cells with two nuclei were rather often seen in which both nuclei were equally covered with silver grains. The percentage of labeled Kupffer cells is markedly higher than that of the labeled epithelial cells of the liver. In the kidney the labeling of the nuclei occurs considerably less often in the epithelial cells of the canaliculi than in the endothelial cells of the glomeruli and of Bowman's capsule. No preference of labeling is given to any parts of the canaliculi. There are no accumulations of labeled nuclei in the different layers of the adrenal cortex. In the pancreatic epithelia and in the islets of Langerhans the number of the labeled nuclei corresponds with the number in the organs mentioned above.

Accumulations of labeled nuclei are found in the peribronchial tissue of the lungs. Within the bronchial tubes the labeled epithelial cells belong partly to the basal and partly to the upper layer of cells of the ciliated epithelium. Labeled nuclei are only sporadically distributed in the single-layered pleural endothelium. There are increased numbers of labeled pleural endothelia over subpleural inflammatory infiltrations. There is a remarkably high number of labeled nuclei of alveolar cells.

It is remarkable that in all parenchymatous organs the number of labeled cells is much smaller in the parenchyma than in the interstitial connective tissue and reticuloendothelial system.

Vegetative intermitotic cells (epithelium of skin and mucous membranes, lymphatic tissues, testicle, connective tissue). In the abdominal skin and in the esophagus, labeled nuclei are found in the basal cellular layer only. In the stomach, labeled cells appear more often in the lower third of the gastric foveolae than in the glands. Only very few labeled nuclei are seen in the Brunner's glands of the duodenum. Almost every other cell of the Lieberkühn's crypts is labeled. The epithelia of the villi are free of labeled nuclei. Similar statements are true for the jejunum and the ileum. In the colon the major density of labeled cells is found just above the bases of the crypts. Some nuclei of large basophil stem cells were labeled in the germinative centers of the spleen and of the lymphatic glands. Few labeled nuclei of large basophil reticular cells were detected in the peripheral zones of the lymphatic follicles and of the Malpighian corpuscles. Accumulations of labeled nuclei are specially found in the sinus of the spleen and originate in the relatively small nuclei of the prolymphocytes (*5*). Here, according to the more solid arrangement of the chromatin, the silver grains are closer

Table 1. Percentage of nuclei labeled by H^3-thymidine and percentage of mitosis, for cells of various organs.

Organ	Kind of cells	H^3 index (% of labeled nuclei)	Mitosis index (% of mitosis)	H^3 index ÷ mitosis index
	Group 1			
Central nervous system	Ganglionic cells	0		
Heart muscle; skeletal muscle	Cells of striated muscle	0		
Gastrointestinal tract	Cells of smooth muscle	0.28		
	Group 2			
Liver	Liver epithelia	0.4	0.04	10
	Kupffer cells	1.2		
Kidney	Epithelia of canaliculi	0.6	0.05	12
	Endothelia of glomeruli	4.0		
Suprarenal gland	Cells of the cortex	0.4	0.04	10
Pancreas	Pancreatic epithelia	0.83	0.073	11
	Cells of Langerhans' islets	0.8		
Lung	Surface cells of alveoli	1.8		
	Bronchial epithelia	1.0		
	Group 3			
Abdominal skin	Basal layer	4.0	0.52	8
Esophagus	Basal layer	20.0		
Duodenum	Epithelia of mucous membrane	17.0	1.1	15
Jejunum	Epithelia of mucous membrane	15.0		
Colon	Lieberkühn's crypts	8.2	0.72	11

packed than over the large nuclei of cells of the germinative centers. The testicles contain canaliculi, in which practically all spermatogonia are labeled with almost an equal number of silver grains. On the other side there are canaliculi without a labeled spermatogonium. Nuclei of spermatocytes and sperms are never labeled within the chosen experimental time intervals. In the connective and adipose tissues, labeled nuclei are found in a surprisingly great number. They apparently form a reservoir of undifferentiated mesenchyme cells with a marked tendency to proliferation (*2*, *6*).

As far as the same organs were examined, these results agree very well with those of Leblond *et al.* (*6*) and of Pelc (*3*) obtained from rats after a single application of H^3-thymidine.

The figures given in Table 1, columns 3 and 4, are in close relationship with the time interval during which deoxyribonucleic acid (DNA) is synthesized, with the duration of the microscopically detectable stages of the metaphase and anaphase of the mitosis, and with the life span of the cell. One may express the H^3 index and the mitosis index as

$$H^3 = \frac{\text{duration of DNA synthesis}}{\text{life span of cell}} \quad (1)$$

$$\text{Mitosis} = \frac{\text{duration of mitosis}}{\text{life span of cell}} \quad (2)$$

If the cell formation in a tissue is due to mitosis only, the divisors in Eq. 1 and Eq. 2 are equal. Then the division of Eq. 1 by Eq. 2 results in

$$\frac{H^3}{\text{Mitosis}} = \frac{\text{duration of DNA synthesis}}{\text{duration of mitosis}} \quad (3)$$

Equations 1 and 2 have a different meaning in the eventual case of amitosis and the formation of nuclei with polyploid chromosome numbers. However, this case cannot be discussed here.

It is remarkable that the quotient H^3 index/mitosis index, which is given in column 5 of Table 1, is almost equal in all investigated tissues and is approximately equal to 10. Even the liver does not differ from this general rule. This means that the duration of the DNA synthesis should be 10 times longer than the duration of the mitosis. This agrees with the present opinion that the DNA synthesis occurs during the interphase and is not connected with the much faster mitosis.

Knowlton and Widner (*7*) reported that the duration of mitosis is equal in different tissues of mice and lasts 20 to 36 minutes. Our own autoradiographic work with H^3-thymidine and H^3-cytidine on the percentage of labeled mitosis figures resulted in a value of 20 to 30 minutes. Assuming that these figures represent the real conditions, the time that DNA synthesis requires would be about the same for all cells and would last about 5 hours. Moreover, the life span of cells of the third group in Table 1 should amount to 1 to 5 days, and that of the cells of the second group 30 to 50 days. These theoretical estimates based on data of the mitosis index are in accord with the results of work already accomplished by others (*7*, *8*). But while mitosis is often not detectable at all, or at least not with certainty, by microscopic examination, it is traceable by radioactive labeling.

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21 September 1959

Genetic Control of Two γ-Globulin Isoantigenic Sites in Domestic Rabbits

Abstract. Results of immunochemical analysis of sera from 335 offspring of 81 litters of rabbits are consistent with the hypothesis that the isoantigenic sites, RGG-I and RGG-II, of the γ-globulins are controlled by a single allelic pair of autosomal genes with both specificities exhibited by the heterozygote. The three genotypes may be designated γ^I/γ^I, γ^{II}/γ^{II}, and γ^I/γ^{II}.

Recent investigations have shown that components from individual rabbits are antigenic in other rabbits (*1–3*). Subsequently, 500 domestic rabbits (*Oryctolagus cuniculus*) of several breeds could be separated into three groups on the basis of two isoantigenically different γ-globulin specificities (*4*). These γ-globulin specificities, designated RGG-I and RGG-II, were demonstrated with specific isoprecipitins by agar gel immunochemical methods. Individual rabbits were found to contain either RGG-I, RGG-II, or both RGG-I and RGG-II in their sera but never lacked both γ-globulin specificities. Of 500 rabbit sera tested, there were 24 with only RGG-I, 379 with only RGG-II, and 97 with both RGG-I and RGG-II (*4*).

The simplest genetic hypothesis for the control of the three phenotypes is that the two isoantigenic sites RGG-I and RGG-II are controlled by a single allelic pair of autosomal genes with both specificities exhibited by the heterozygote. The three genotypes may be designated γ^I/γ^I, γ^{II}/γ^{II}, and γ^I/γ^{II} and correspond to the phenotypes RGG-I, RGG-II, and RGG-I/RGG-II. Of the 500 rabbits, 162 were from a small closed colony of Flemish giants (4 sires, 20 dams) at the National Institutes of Health which are bred according to a plan to minimize inbreeding and thus possibly approach the conditions of the Hardy-Weinberg law (*5*). The distribution of RGG groups among this population was as follows: 19 RGG-I, 68 RGG-II, and 75 RGG-I/RGG-II (*6*). According to the hypothesis, the gene frequencies would be $.35\gamma^I$ and $.65\gamma^{II}$. When the Hardy-Weinberg formula is applied for these gene frequencies in a random-bred population of 162, the expected distribution of phenotypes is calculated to be 19.8 RGG-I, 68.4 RGG-II, and 73.8 RGG-I/RGG-II, in close agreement with the experimental findings (probability, .98 to .99).

The purpose of this investigation was to test the above genetic hypothesis directly by analysis of the progeny of 81 litters of domestic rabbits obtained from all six possible matings of the three groups for the presence of RGG-I and RGG-II in their sera.

The γ-globulin isoantigenic sites RGG-I and RGG-II were identified in the sera by the agar gel methods described previously (*2*, *4*). The sera were obtained from 8- to 9-week-old rabbits. As a control for the absence of maternal γ-globulin, many of the offspring were tested again several months to a year after the initial test, and such tests always confirmed the original typing of the sera obtained at 8 to 9 weeks. Of 335 progeny tested, 208 were produced by the animal production section of NIH (*7*), 90 by a commercial breeder (*8*), and 37 by our own laboratory. Only in our own laboratory was breeding selective on the basis of known γ-globulin phenotypes.

Table 1 presents the γ-globulin phenotypes of the 335 offspring. The experimentally determined distribution of progeny among the three γ-globulin groups is generally in accord with the genetic hypothesis.

The unexpected deviation of the experimentally determined and theoretically expected RGG groups of the offspring resulting from the backcross

Table 1. Hypothesis of genetic control of γ-globulin isoantigenic sites by an allelic pair of autosomal genes tested by examining progeny from 81 litters of domestic rabbits resulting from all six possible matings among the three known phenotypes, namely those with only RGG-I, only RGG-II, and both RGG-I and RGG-II in their sera.

RGG group of parents		Litters (No.)	Progeny (No.)	No. of progeny in each RGG group						Probability
				Experimental			Theoretical			
Dam	Sire			I	II	I/II	I	II	I/II	
I	I	2	9	9	0	0	9	0	0	
II	II	27	125	0	125	0	0	125	0	
I	II	4	12	0	0	12				
II	I	5	17	0	0	17				
Totals		9	29	0	0	29	0	0	29	
I	I/II	6	25	4	0	21				
I/II	I	5	10	7	0	3				
Totals		11	35	11	0	24	17.5	0	17.5	.02–.05
II	I/II	16	69	0	37	32				
I/II	II	3	13	0	5	8				
Totals		19	82	0	42	40	0	41	41	.8–.9
I/II	I/II	13	55	14	15	26	13.7	13.7	27.5	.8–.9
Test for no association with sex										
180 bucks				17	98	65	18.3	97.8	64	
155 does				17	84	54	15.7	84.2	55	.90–.95
335 progeny				34	182	119				

to RGG-I rabbits could have occurred by chance alone but might be related to the fact that four of the litters, comprising 17 rabbits, were offspring of the same parents. Only one of these offspring was an RGG-I phenotype, while the other 16 were RGG-I/RGG-II phenotypes.

A study of litters of the sire and dam with other mates might lead to possible explanations of the deviations observed. The RGG-I/RGG-II sire had given rise to five litters with three RGG-II dams to yield 11 RGG-II and 12 RGG-I/RGG-II phenotypes, in close agreement with the hypothesis. Unfortunately, the sire is no longer available for other matings, but heterozygote buck and doe offspring are available which have the γ^{I} allele derived from the sire. A pair of such heterozygotes gave rise to two litters with a phenotype distribution of 1 RGG-I, 7 RGG-II, and 10 RGG-I/RGG-II (probability, .1 to .2), again suggesting some difficulty in yielding RGG-I phenotypes. The RGG-I dam of the four deviant litters is still available, and perhaps phenotypes of her offspring will give additional clues for investigation of factors, possibly lethal or semilethal, which might be associated with the less frequently occurring allele, γ^{I}.

As of now, 1006 domestic rabbits (*Oryctolagus cuniculus*) of more than 16 breeds have been typed according to their γ-globulin isoantigenic sites: 61 were type RGG-I, 749 were RGG-II, and 196 were RGG-I/RGG-II. In addition, four San Juan rabbits (*Oryctolagus cuniculus*), obtained from the San Juan Islands, Washington (derived from European stock prior to the myxoma epizootic and living in the wild state) were typed RGG-II (*9*). Only a few of the colonies tested showed the presence of the γ^{I} gene, beyond that of an occasional heterozygote. The fact that no domestic rabbits have been found with neither RGG-I nor RGG-II is further corroboration of the genetic hypothesis but does not exclude the possibility of additional alleles at the same locus present at low frequency (*10*). Also, it must be emphasized that γ-globulin is a heterogeneous mixture of proteins and that the genetic conclusions pertain only to the isoantigenic portion of those molecules which have the site in question.

The isoantigens should be useful in the study of differentiation of species. The sera of other lagomorphs, namely, 28 cottontail rabbits (three or four species of *Sylvilagus*), 24 jack rabbits (*Lepus californicus deserticola*), 2 snowshoe hares (*Lepus americanus*), and 2 pikas (*Ochotona collaris*), were tested for RGG-I and RGG-II with isoprecipitins of the domestic rabbits, and none were found to have either RGG-I or RGG-II (*11*). Neither did the sera of guinea pig, rat, mouse, hamster, chicken, sheep, horse, cat, dog, monkey, or man show any RGG-I or RGG-II. Thus it would appear that these isoantigenic sites are genus-specific.

In the heterozygotes, the allelic genes are most likely to produce two distinct γ-globulins, each indistinguishable from the γ-globulin of the corresponding homozygote. Nevertheless, hybrid substances are known to occur, and this question is under investigation (*12*).

The molecules having isoantigenic sites under the genetic control postulated in this report (*13*) are soluable proteins, namely γ-globulins. Some of these molecules may also react as antibodies. As antigens, precipitable by antibodies, they should be subject to quantitative estimation and cytological studies. Moreover, these γ-globulins may be expected to pass through maternal-fetal barriers. Thus, this immunogenetic system may be uniquely suited for investigation of some basic problems in genetics, embryology, immunology, and protein chemistry. Investigations of other protein isoantigens in serum and of such isoantigens in other tissues and species should also be encouraged (*14, 15*).

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6. Paper presented at the annual meeting of the Biophysical Society, Pittsburgh, Pa., 25 Feb. 1959.
7. We express our gratitude to Samuel M. Poiley and Robert D. Dettman of the animal production section of NIH for their helpful advice and assistance throughout the course of this work.
8. Thompson's Rabbit Farm, Reisterstown, Md.
9. We thank Murray L. Johnson, Tacoma, Wash., for the sera of San Juan rabbits.
10. Subsequent to our submitting this report for publication, S. Dubiski (Institute of Haematology, Warsaw, Poland) kindly sent us a sample of serum from one rabbit (No. 394) which has neither RGG-I nor RGG-II, suggesting that an additional allele may be present at the same locus in some rabbit populations.
11. Our thanks are expressed for gifts of lagomorph sera from Richard E. Shope, Samuel B. Salvin, Robert Rausch, Murray L. Johnson, Herbert T. Dalmat, and Griffith E. Quinby.
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13. This paper was presented at the annual meeting of the Genetics Society of America, Pennsylvania State University, 31 Aug. 1959.
14. We have recently identified a third γ-globulin isoantigenic site, RGG-III, in the sera of domestic rabbits. The genetic and immunologic relationships of RGG-III to RGG-I and RGG-II are being investigated.
15. Comparison of our isoimmune sera with isoimmune sera received recently from Dr. Dubiski corroborates his personal communication to the effect that he and his collaborators have found still more γ-globulin isoantigens.

30 September 1959

Sexual Dimorphism of Rat Cells in vitro

Abstract. Large peripheral chromocenters occurred in about 10 percent of the nuclei of female rat cells grown in vitro but occurred on the average in less than 1 percent of the nuclei of male cells. Similar chromocenters occurred in hamster and mouse nuclei in vitro, but no clear-cut sexual difference was demonstrable.

A distinct sexual dimorphism has been established for the interphrase nuclei of many mammalian species, especially in the orders Primate and Carnivora (*1*). This dimorphism depends on the presence of the sex chromation body of Barr in the nuclei of female cells. Study of the metabolic and genetic aspects of Barr chromatin might be facilitated if the chromatin were found to be present in a small laboratory animal such as the rat, mouse, or hamster. Moore and Barr (*2*) were unable to detect a nuclear sex difference in these animals. Subsequently, however, sex chromatin was reported in motor neurons (*3*), liver cells (*4*), and ameloblasts (*5*) of female rats, although in the first two of these reports the relative incidence is not specified. In addition, it has been reported that sex chromatin occurs in the neurons of female golden hamsters (*6*); again, the incidence is not specified.

Hinrichsen and Gothe (*7*) have recently published a detailed study of the chromatin patterns in the rat and mouse. They report that nearly half the nuclei of Purkinje cells of female rats have a solitary peripheral chromocenter. While they did not find many peripheral chromocenters in mouse nuclei, they do report a sex difference based on the size and number of nucleolar chromocenters. Although exact parallelism between the chromatin patterns of cells in vitro and in vivo remains to be demonstrated, it has been noted that the sex chromatin body may be more readily identifiable in tissue cultures, and in at least one case (*8*) the sex chromatin body has been demonstrated in culture when it could not be identified in tissue section.

With the thought that a comparable situation might obtain with respect to the more complex chromatin patterns in rodents, we employed two methods of cell culture, using heart, spleen, and kidney from the Sprague-Dawley strain of *Rattus norvegicus* (*9*). Three rats of each sex were sacrificed. Tissues were trypsinized, and aliquots were plated and incubated on cover slips in petri dishes, by a method described elsewhere (*10*). Small fragments were also explanted in plasma clots on cover slips by the method of Southam and Goettler (*11*). Cultures were incubated for periods ranging from 6 to 33 days, after which the cover slips were treated in accordance with the thionin staining procedure of Klinger and Ludwig (*12*).

Many nuclei showed a solitary peripheral chromatin mass which varied from about 0.5 to 1.0 μ in width and from about 1.0 to 1.8 μ in length (average, about 0.8 by 1.4 μ). As shown in Table 1, the incidence in female tissues varied from 1 to 22.1 percent and in male tissues, from 0 to 2.8 percent; all percentages are based on counts of at least 500 nuclei. Corresponding averages were 11.20 and 0.89 percent. There was no correlation with the tissue of origin or with the age of the culture. In general, cells from kidney tissue were epitheloid, while cells from heart and spleen were fibroblast-like. There did not appear to be any consistent difference in size or morphology between peripheral chromatin bodies in male and female cells.

Table 1. Percentages of peripheral chromocenters in 500 nuclei (S, spleen; H, heart; K, kidney).

Culture No.	Percentage	Tissue	Days cultured
	Female, trypsinized cells		
1	11.2	S	14
2	13.0	S	14
3	10.0	S	7
4	17.4	H	14
5	10.7	S	14
6	19.6	K	14
7	9.4	K	33
8	10.4	H	14
9	10.4	H	14
10	8.5	K	14
11	17.0	K	16
12	10.2	S	16
13	6.8	S	14
	Female, fragments explanted in plasma		
14	3.6	K	9
15	22.1	K	6
16	5.3	K	14
17	23.0	H	6
18	15.4	S	9
19	1.0	K	9
20	4.6	H	9
21	14.4	S	9
22	10.4	H	9
23	2.7	K	14
	Male, trypsinized cells		
1	0.3	S	7
2	1.0	S	17
3	1.2	S	7
4	2.8	S	7
	Male, fragment explants		
5	0	K	9
6	0	K	9
7	0.8	S	9
8	0.8	K	9
9	0.8	H	9
10	1.2	H	9

Fragment explants from heart, spleen, and kidney were also made from one individual of each sex of the golden hamster (*Cricetus auratus*) and from two individuals of each sex of the mouse (*Mus musculus*). No clear-cut sexual dimorphism was observed in these cultures. The hamster nuclei frequently showed solitary peripheral chromatin bodies. In seven female cultures the incidences were 10, 34, 19, 30, 36, 64, and 12 percent, respectively. In five male cultures the corresponding percentages were 4, 5, 11, 8, and 21. (These figures are based on counts of 100 nuclei.)

Mouse nuclei in vitro showed multiple chromocenters, the exact number often being difficult to determine since the chromocenters frequently vary in size down to the limits of visibility. However, a single nucleus may contain 10 to 20 large chromocenters (comparable in size to the sex chromatin body) and rarely lacks at least one or two. Such chromocenters often occurred at the nuclear membrane in both sexes. There was no apparent sex difference with respect to incidence or morphology. However, the morphologic variants often strikingly resembled those which have been described for sex chromatin in cultured human cells (*10*, *13*).

CHARLES P. MILES
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29 October 1959

Kodak reports on:

the question of whether or not instrumentation people really need ultra-fast film . . . a new gravimetric reagent for potassium . . . a gimmick the committee needn't resist . . . new hope for those who can't get enough light for Kodachrome Film, Type A

1600—no waiting

How come after all those promises we have made to innumerable instrumentation people over the years that some day there would be 16mm, 35mm, and 70mm film as fast as *Kodak Royal-X Pan Recording Film* now is—Index 1600—how come we now find ourselves in the ridiculous position of being able to make it at a greater rate than they're buying it? How come?

Don't they know that a note or phone call to Eastman Kodak Company, Photo Recording Methods Division, Rochester 4, N. Y., will set up the channel to supply it through a local dealer?

Made in U. S. A. under hygienic conditions

The Japanese have developed a new gravimetric reagent for potassium which we now offer as *N-(2,4-Dinitro-1-naphthyl)benzenesulfonamide* (Eastman 7828). And regardless of how scarce are good gravimetric reagents for potassium that can be used even in the presence of one-third as much sodium and magnesium as potassium, if that numeral in front of the "naphthyl" in the name had been 2 instead of 1, we would not offer it as Eastman 7828 or Eastman anything else. Our medical director feels so strongly about the carcinogenic properties of β-naphthylamine that it would seem wiser to let the science of chemistry go shift for itself than to observe the safety precautions he demands before he will let it into the plant. Pure α-naphthylamine is OK, as far as we know.

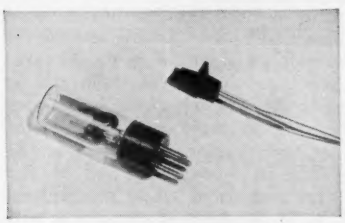
You dissolve the new reagent in lithium chloride solution and use it for the precipitation and conductometric titration of potassium. The precipitated potassium salt of the reagent is washed with the saturated solution of potassium salt and dried at 100°C for an hour. As for the fine details of the procedure, you can either buy 10 grams of Eastman 7828 from us for $4.45 and work them out for yourself, or you can first read up on them in *Nippon Kagaku Zasshi, 79,* 598 (1958).

When you're ready, you send your $4.45 to Distillation Products Industries, *Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company). In case you didn't know, there are some 3800 other Eastman Organic Chemicals on the shelf there.*

Silicon over the sound track

Quietly, Kodak Pageant Sound Projectors have stolen a march, scored a scoop in their field. You have heard of the "solar battery" which generates useful electrical power when light falls on silicon? The power source for communication from satellites and interplanetary space? Here it is, in over-the-counter civilian hardware, doing a product-improvement job that is apparent even to those who can resist the temptation of a gimmick. If you are on a committee to select a sound movie projector for audio-visual instruction, the facts to lay before your fellow committeeman are these:

Early attempts at sound movies through a variable light pattern on the film employed selenium cells. They foundered. An EMF-generating selenium cell (not to be confused with a device that changes resistance in response to light) has an inherently slow time constant for adequate frequency response. The movies had to wait for the evacuated phototube to give them a good voice.



At left is a phototube such as employed today in most sound projectors. Being a little bulky, light that has passed through the sound track of the film must be somehow transmitted to it. At right is the new silicon "solar" cell. It holds 0.014 square inch of silicon directly above the sound track. It therefore requires a less critical optical arrangement. More important, it generates a varying EMF instead of valving from a constant EMF that must be supplied to it. This considerably simplifies the circuitry. There is less to get out of whack. Also, a solid-state generator happens to generate less random fluctuation than a photocathode system that must be kept under electrical tension. Less "white noise" shows up at the speaker. The old trouble from inadequate frequency response with selenium is gone.

If the old boys had known enough solid-state physics to place their bets on silicon instead of selenium, people with vivid memories of the silent movie queens would be even older, on the average, than they feel as it is.

We are talking about Kodak Pageant Sound Projectors, Models 8K5, AV-085, *and* AV-255-S. *Your local audio-visual dealer will take it from here.*

Endography, with action and color

The world is crazy. It flagellates itself into technological advances on the pretext of military preparedness. For this, nothing is too much trouble. If it finds one such advance to be applicable to peaceful purposes, such as the healing arts, it is as happy as an idiot who in his rage has turned up a pretty pebble.

Ektachrome ER Film has recently been brought out under pressure of the missile industry, which needs color film of very high sensitivity for the high speed movie cameras they use in their testing work. Could anybody else use such a film? Yes, come to think of it.

Physicians interested in endoscopic color photography might find it useful. To get enough light for good color photography into the cavities of the living body has been difficult. Motion pictures, which afford the possibility of thorough scanning of an area with a large number of individual images, better the chances for decisive demonstration.

Here and there might be found a medical man so inflamed with zeal to sharpen his diagnostic procedures as to feel excitement in the idea of seeing what he can see with a color film eight times as fast as *Kodachrome Film, Type A* through a gastroscope, bronchoscope, proctoscope, laryngoscope, colposcope, otoscope, or sigmoidoscope.

If he will write to Eastman Kodak Company, Medical Division, Rochester 4, N. Y., and ask about Ektachrome ER Film, Type B *we shall try to advise him on the photographic part of his problem.*

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Kodak
TRADE MARK

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

Meetings

Biophysics

At the general assembly of the International Union of Pure and Applied Physics, which took place in Rome in September 1957, some discussion arose on the desirability of setting up a commission on biophysics within that union. An *ad hoc* committee consisting of R. H. Bolt (United States), A. Joffe (U.S.S.R.), and G. B. B. M. Sutherland (Great Britain) was appointed to look into the matter. This committee recommended (among other things) that an international conference on biophysics be held, which would bring together a representative selection of physicists and biologists and so allow wider discussion of the need for an international organization in biophysics and of the form it might take if its establishment were deemed desirable. The executive committee of the IUPAP endorsed this recommendation in 1958 and asked that the conference be held in 1959. This conference was held in Cambridge, England, from 6 to 9 July, and was attended by over 150 physicists, biophysicists, and biologists from 16 different countries.

In order to have as representative a gathering as possible, the organizers of the conference decided it would be best to have a series of authoritative lectures on a wide variety of topics, illustrating the contribution which physics is making to certain important problems in biology. The proceedings of this conference will not be published, since there was relatively little new material presented, one of the main purposes of the conference being that of enabling biophysicists engaged on very different problems to know more about what their colleagues are doing and to exchange ideas.

The conference was opened by A. V. Hill, who emphasized that biophysics is much more than the mere use of physical instruments and techniques in biological problems. In so far as it can be defined (and this is a very controversial matter), it is rather a method of thinking or a method of attack in which physical and biological concepts are blended in the investigation of vital processes. Linus Pauling (Pasadena) then spoke on the contribution of physics to our knowledge of protein structure; he was followed by M. Delbruck (Pasadena), who spoke on the structural aspects of molecular genetics.

The second day was devoted to papers on the contribution of physics to the study of muscle (D. R. Wilkie of University College, London); on the mechanism of nervous conduction (A. L. Hodgkin of Cambridge); and on virus structure and replication (Robley Williams of the University of California at Berkeley and E. Kellenberger of Geneva). Interesting papers were also presented on anomalous magnetic properties of nucleic acid (by Blumenfeld of Moscow) and on the relation between fibrous protein configurations and their chemical structure (by K. Andreeva of Moscow).

On the morning of the third day a general discussion was held on whether there is a need for an international organization in biophysics and on what form such an organization should take. A brief account of this discussion is given below. The other two papers presented that day were on physical methods of investigating cell structure (A. Engstrom of Stockholm) and on the physical analysis of visual mechanisms (W. A. H. Rushton of Cambridge and K. O. Donner of Helsinki).

On the morning of the last day, papers were given on the storage and transmission of information in the mammalian brain (Delisle Burns of Montreal) and on the effects of ionizing radiation on living cells (L. H. Gray of London). The afternoon session was devoted to a general discussion on the organization of teaching and research in biophysics. This discussion was opened by J. T. Randall (of London), who strongly emphasized the need for greater recognition of biophysics in universities. This provoked a very lively discussion in which several physiologists expressed their concern lest formalizing the study of biophysics in universities might have harmful effects on departments of physiology.

All of the main lectures were followed by interesting discussions—possibly all the more interesting because it had been agreed beforehand that no record would be made of the discussion. Indeed, the rather informal nature of the whole meeting seemed to meet with general approval.

The discussion on the international organization of biophysics lasted 2 hours. Although widely divergent views on the need and the best form for such an organization were forcibly expressed, a surprising degree of unanimity was revealed when the voting took place. Most of the first hour was devoted to arguments for and against setting up any form of international organization. The majority in favor of establishing some form of organization was approximately ten to one. As a result of the subsequent discussion, three possible forms of organization were proposed: (i) that special commissions in biophysics be established independently inside two or more of the present international unions (for example, Physics, Physiology, or Biology); (ii) that steps be taken to establish an affiliated commission (similar to that in optics) in association with the International Union of Pure and Applied Physics; (iii) that an independent international organization in biophysics be created which might eventually apply for admission to the International Council of Scientific Unions.

Neither of the first two proposals received more than three votes. The third proposal was carried by an overwhelming majority. It was agreed that it was neither practicable nor desirable for the new organization to be created at the 1959 meeting. National biophysical societies already exist in various countries, and these will presumably act as nuclei from which an international society will emerge. However, in order to provide a focus for communication, the meeting designated a provisional secretary (Professor R. H. Bolt, National Science Foundation, Washington 25, D.C.), to whom inquiries and suggestions may be sent.

R. H. BOLT*
National Science Foundation, Washington, D.C.
G. B. B. M. SUTHERLAND
National Physical Laboratory, Teddington, Middlesex, England

Note

* On leave from Massachusetts Institute of Technology.

Forthcoming Events

April

4–8. American Meteorological Soc., 3rd applied meteorology conf., Santa Barbara, Calif. (H. G. Houghton, AMS, Dept. of Meteorology, Massachusetts Inst. of Technology, Cambridge 39.)

4–8. American Soc. of Mechanical Engineers, New York, N.Y. (D. B. MacDougall, ASME, 29 W. 39 St., New York.)

4–9. American College of Physicians, San Francisco, Calif. (E. R. Loveland. 4200 Pine St., Philadelphia 4.)

5–7. Instrument Soc. of America (Natl. Chemical and Petroleum Symp.), Rochester, N.Y. (H. S. Kindler, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

5–7. Naval Structural Mechanics, 2nd symp., Providence, R.I. (E. H. Lee, Brown Univ., Providence.)

5–14. American Chemical Soc., natl., Cleveland, Ohio. (A. T. Winstead, ACS, 1155 16 St., NW, Washington 6.)

6. The Allergic Child, symp., New Haven, Conn. (V. L. Szanton, Hospital of St. Raphael, New Haven 11.)

6–8. Biochemistry and Pharmacology of Compounds Derived from Marine Organisms, symp., New York, N.Y. (R. F. Nigrelli, Dept. of Marine Biochemistry and Ecology, New York Aquarium, Seaside Park, Eighth St. and Surf Ave., Brooklyn 24, N.Y.)

6–8. Hyper-Environments—Space Frontier (Inst. of Environmental Scientists), Los Angeles, Calif. (M. S. Christensen, IES, 6251 Marita St., Long Beach 15, Calif.)

6–8. Radiofrequency Spectroscopy Group, Nottingham, England. (J. E. Ingram, RSG, c/o Dept. of Electronics. Telecommunications and Radio Engineering, Univ. of Southampton, England.)

6–8. Structural Design of Space Vehicles, conf., Santa Barbara, Calif. (A. F. Denham, 925 Book Bldg., Detroit 26, Mich.)

6–9. Mineral Processing, intern. cong., London, England. (B. W. Kerrigan, Institution of Mining and Metallurgy, 44 Portland Pl., London, W.1, England.)

7–8 Cathode Protection, European symp., Frankfort am Main, Germany. (Secrétariat du Symposium, Deutsche Gesellschaft fur Metallkunde, Alteburgerstrasse 402, Koln-Marienburg, Germany.)

7–8. Municipal and Industrial Waste, 9th southern conf., Raleigh, N.C. (C. Smallwood, Jr., North Carolina State College, Extension Div., Box 5125, Raleigh.)

7–9. American Assoc. of Railway Surgeons, Chicago, Ill. (C. C. Guy, 5800 Stoney Island Ave., Chicago 37.)

7–9. Association of Surgeons of Great Britain and Ireland, Birmingham, England. (F. A. R. Stammers, 47 Lincolns Inn Fields, London, W.C.2, England.)

7–9. Optical Soc. of America, Washington, D.C. (K. S. Gibson, OSA, Natl. Bureau of Standards, Washington 25.)

8–9. American Assoc. of University Professors, Detroit, Mich. (P. R. David, Univ. of Oklahoma, Norman.)

8–9. New Mexico Acad. of Science, Socorro. (K. G. Melgaard, P.O. Box 546, University Park, N.M.)

8–9. Southern Soc. for Philosophy and Psychology, Biloxi, Miss. (E. Henderson, Florida State Univ. Tallahassee.)

8–11. American Dermatological Assoc., Boca Raton, Fla. (W. M. Sams, 308 Ingraham Bldg., Miami 32, Fla.)

9–10. Histochemical Soc., 11th annual, New York, N.Y. (H. W. Deane, Albert Einstein College of Medicine, Bronx 61, N.Y.)

10–11. American Soc. for Artificial Internal Organs, Chicago, Ill. (C. K. Kirby, ASFAIO, 3400 Spruce St., Philadelphia 4, Pa.)

11–13. American College of Surgeons, Minneapolis. Minn. (H. P. Saunders, 40 E. Erie St., Chicago 11, Ill.)

11–13. Electrical Engineering in Space Technology, 1st conf. (AIEE), Dallas, Tex. (B. J. Wilson, Naval Research Laboratory, Washington, D.C.)

11–13. Forest Tree Growth, intern. conf., Tucson, Ariz. (Forest Tree Growth Conf., Laboratory of Tree-Ring Research, Univ. of Arizona, Tucson.)

11–14. American College Personnel Assoc., Philadelphia, Pa. (M. D. Hardee, Florida State Univ., Tallahassee.)

11–14. American Meteorological Soc., 8th weather radar conf., San Francisco, Calif. (H. G. Houghton, AMS, Dept. of Meteorology, Massachusetts Inst. of Technology, Cambridge 39.)

11–15. American Assoc. of Immunologists, Chicago, Ill. (C. Howe, Columbia Univ., College of Physicians and Surgeons, New York 22.)

11–15. American Inst. of Nutrition, Chicago, Ill. (G. M. Briggs, Div. of General Medical Sciences, National Institutes of Health, Bethesda, Md.)

11–15. American Physiological Soc., Chicago, Ill. (R. G. Daggs, 9650 Wisconsin Ave., NW, Washington 14.)

11–15. American Soc. for Experimental Pathology, Chicago, Ill. (F. J. A. McManus, Univ. of Alabama Medical Center, Birmingham.)

11–15. American Soc. for Pharmacology and Experimental Therapeutics, Chicago, Ill. (K. H. Beyer, Merck, Sharp & Dohme Research Laboratories, West Point, Pa.)

11–15. Federation of American Socs. for Experimental Biology, Chicago, Ill. (M. O. Lee, 9650 Wisconsin Ave., NW, Washington 14.)

11–16. American Assoc. of Anatomists, New York, N.Y. (L. B. Flexner, Dept. of Anatomy, School of Medicine, Univ. of Pennsylvania, Philadelphia 4.)

11–16. American Soc. of Biological Chemists, Chicago, Ill. (F. W. Putnam, Dept. of Biochemistry, Univ. of Florida, Gainesville.)

11–16. Anatomical Congress, 7th intern., New York, N.Y. (D. W. Fawcett, Dept. of Anatomy, Harvard Medical School, Boston 15, Mass.)

11–16. Congress of Anatomy, 7th intern., New York, N.Y. (J. C. Hinsey, New York Hospital, Cornell Medical Center, 525 East 68 Street, New York 21, N.Y.)

12–13. Microbial Genetics, symp., London, England. (B. W. Lacey, Soc. for General Microbiology, Dept. of Bacteriology, Westminster Medical School, London, S.W.1.)

13–15. American Public Health Assoc. (Southern Branch), Memphis, Tenn. (L. M. Groves. Shelby County Health Dept., Memphis.)

15–16. Eastern Psychological Assoc., New York, N.Y. (C. H. Rush, Standard Oil Co. (N.J.), Rockefeller Plaza, New York, N.Y.)

16. Pennsylvania Acad. of Science, Williamsport. (K. B. Hoover, Messiah College, Grantham, Pa.)

18–19. Radioactivity in Man, Measurements and Effects of Internal Gamma Ray Emitting Radiosotopes, AAAS symp., Nashville, Tenn. (G. R. Meneely, School

of Medicine, Vanderbilt Univ., Nashville 5.)

18–21. American Astronomical Soc., Pittsburgh, Pa. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

18–22. Association of American Geographers, Dallas, Tex. (A. C. Gerlach, Map Div., Library of Congress, Washington 25.)

18–22. European Soc. of Ophthalmology, 1st cong., Athens, Greece. (P. Velissaropoulis, c/o Ophthalmology Clinic, Faculty of Medicine, 26, rue de l'Université, Athens, Greece.)

19–21. Active Networks and Feedback Systems, 10th intern. symp., New York, N.Y. (H. J. Carlin, Microwave Research Inst., Polytechnic Inst. of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.)

19–21. American Soc. of Lubrication Engineers, annual, Cincinnati, Ohio. (C. L. Willey, ASLE, 84 E. Randolph St., Chicago, Ill.)

19–22. Metallurgy of Plutonium—session on nuclear fuels, intern, symp., Grenoble, France. (Société Française de Métallurgie, 25, rue de Clichy, Paris, France.)

20–21. Council on Medical Television, 2nd meeting, Bethesda, Md. (J. Mackenzie, Council on Medical Television, 33 E. 68 St., New York 21.)

20–22. Biological Waste Treatment, 3rd conf., New York, N.Y. (W. W. Eckenfelder, Dept. of Civil Engineering, Manhattan College, New York 71.)

20–22. Manned Space Stations Inst. of the Aeronautical Sciences symp., Los Angeles, Calif. (E. Levin, Rand Corp., 1700 Main St., Santa Monica, Calif.)

20–22. Medical Electronics, natl. conf., Houston, Tex. (K. O. Heintz, Humble Oil and Refining Co., Houston.)

20–22. Southwestern Inst. of Radio Engineers, 12th annual, Houston, Tex. (H. E. Childers, College of Medicine, Baylor Univ., Waco, Tex.)

20–23. National Council of Teachers of Mathematics, Ann Arbor, Mich. (M. H. Ahrendt, 1201 16 St., NW, Washington 6.)

20–24. Congress of Gastroenterology, 6th intern., Leyden and Noordwiik aan Zee, Netherlands. (C. Schreuder, 16, Lange Voorhout, The Hague, Netherlands.)

21–23. Association of Southeastern Biologists, New Orleans, La. (H. J. Humm, Dept. of Botany, Duke Univ., Durham, N.C.)

21–28. American Soc. of Tool Engineers, annual, Detroit, Mich. (H. E. Conrad, ASTE, 10700 Puritan Ave., Detroit 38.)

22–23. High-Temperature Resistance and Thermal Degradation of Polymers, symp., London, England. (Symposium Sub-Committee, Plastics and Polymer Group, Soc. of Chemical Industry, 14 Belgrave Sq., London, S.W.1, England.)

24–28. American Ceramic Soc., annual, Philadelphia, Pa. (F. P. Reid, ACS, 4055 N. High St., Columbus 14, Ohio.)

25–27. American Proctologic Soc., Houston, Tex. (N. D. Nigro, 10 Peterboro, Detroit 1, Mich.)

25–27. Canadian Inst. of Mining and Metallurgy, 62nd annual, Toronto, Ontario, Canada. (Secretary-Treasurer, Room 906, Drummond Bldg., 1117 St. Catherine St., Montreal, Canada.)

(See issue of 19 February for comprehensive list)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to the manufacturer. Include the department number in your inquiry.*

■ HIGH-IMPEDANCE VOLTMETER measures d-c or low-frequency a-c up to 250 volts in 11 ranges. Input impedance is said to be greater than 10^{17} ohms. Output impedance is less than 10 ohms. Voltage-following accuracy is said to be ±0.02 percent at the low impedance output and better at higher impedance output, with over-all accuracy ±2 percent. Accessories include an integrator for d-c analog signals, decade shunt, voltage divider for range extension, charge detector, regulated voltage supply, and precision current regulator. (Halex Inc., Dept. Sci398, 310 East Imperial Highway, El Segundo, Calif.)

■ NETWORKS for analog operational amplifiers are said to be held to total summing accuracy as high as ±0.005 percent without trimming potentiometers or capacitors. According to the manufacturer, a series network with as many as 10 inputs for a computing amplifier operating at 400 cy/sec may be made with a total in-phase summing error of ±0.01 percent and a total quadrature error of ±0.02 percent. (Julie Research Laboratories, Inc., Dept. Sci403, 556 W. 168 St., New York 32, N.Y.)

■ RADIOMETER is designed for measurement of short pulses of very intense thermal radiation. Water cooling permits the instrument to be used for continuous measurements of the highest intensities currently produced in solar or arc furnaces. The effective area of 0.001 $in.^2$ permits exploration of flux distributions. Response time is 0.01 sec. (Arthur C. Ruge Associates Inc., Dept. Sci404, Hudson, N.H.)

■ TAPE TENSIOMETER measures steady-state and transient tensions experienced by magnetic tape in tape recorder transports. Tension range is 0 to 8 lb. Useful dynamic range is said to exceed 60 db, and the instrument is said to respond to transients with rise time of 1 msec or less. Insertion of the tensiometer requires a clear area of ¾ by 3/16 in. and a clearance of ¼ in. between the recorder deck and the tape edge. Both ¼ and ½ in. tapes are accommodated. Output is amplitude modulation of a 2000 cy/sec carrier, the latter supplied by an external oscillator. Sensitivity is about 115 mv/oz with a built-in transistorized amplifier. Direct output is 1.3 mv/oz. (General Kinetics Inc., Dept. Sci409, 555 23rd St. S, Arlington 2, Va.)

■ BLACK BODY, model 403, is designed to emit black-body radiation over the temperature range 500° to 1000°K. The radiation source temperature is said to be maintained within ±1°K despite wide changes in ambient temperature, line voltage variations, transients, and tube aging, by a combination of vacuum-tube amplifier and thyratron circuitry in a power-proportioning temperature controller. (Infrared Standards Laboratory, Dept. Sci408, 10555 Magnolia Ave., Riverside, Calif.)

■ AUTOMATIC TENSION CONTROL for spooling and unspooling of very-fine-gage wire has a tension-control range of 1.5 to 140 gm with winding speeds from 0 to 1000 ft/min for a spool of 2-in. outside diameter. Spool sizes up to 4.5 in. in maximum diameter can be accommodated. Tension is sensed by a spring-controlled dancer arm. Motion of the arm regulates the voltage and phasing of a servomotor to correct changes. An automatic brake stops the mechanism in the event of filament breakage or power failure. (Diehl Manufacturing Co., Dept. Sci418, Somerville, N.J.)

■ PULSE GENERATOR, model PG-3, is a transistorized instrument that produces pulses with rise times said to be shorter than 0.4 nsec (10^{-9} sec). Repetition rate is variable from 20 to 300 pulses per second, fixed at 60 and 120 pulses per second, or externally controlled. Calibrated pulse widths are 1.7, 5, 10 and 20 nsec with other widths obtainable by use of added cable. Pulse amplitude is 0 to +100 volts, adjustable by a ten-turn potentiometer. (Lumatron Electronics, Inc., Dept. Sci410, 68 Urban Ave., Westbury, N.Y.)

■ RECORDING MICROAMMETER has a basic range of 0 to 50 μa d-c with input resistance approximately 200 ohm. Voltage ranges 0 to 10, 50, and 200 mv d-c are also provided. The instrument combines a magnetic amplifier operating on 120-volt, 60-cy/sec power with a permanent-magnet, moving-coil movement. Accuracy is said to be ±2 percent. Chart speeds of ¾ in./hr through 12 in./min are standard in portable or permanently mounted models. (Esterline-Angus Co., Dept. Sci412, Box 596, Indianapolis 6, Ind.)

■ AUTOMATIC WIRE CUTTER cuts hook-up wire and sleeving at the rate of 1000 ft/hr. Length of wire desired from 2.5 to 25 in. is set into the machine by dial. A predetermining counter is set to stop the cutter after any number of pieces up to 500 have been cut. (Electronic Industries, Dept. Sci417, 2624 Perliter St., North Las Vegas, Nev.)

JOSHUA STERN
National Bureau of Standards, Washington, D.C.

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POSITIONS OPEN

Bacteriologist. $7938–$9138 annually. Position open in clinical bacteriology at large suburban Detroit hospital near University of Michigan and Wayne State University. Well-equipped laboratory available for research, liberal annual and sick leave, retirement plan plus social security. Ph.D. required. Contact Dr. S. E. Gould, Director of Pathology, Wayne County General Hospital, Eloise, Michigan. 3/11; 3/18

POSITIONS OPEN

Biochemist, Ph.D., to work in biological research establishment. Box 59, SCIENCE. X

BIOLOGICAL SCIENTIST

Well-known pharmaceutical firm located in Philadelphia has opening available for alert individual having M.S. or B.S. in the pre-clinical sciences. Some foreign language ability also desirable. Must be interested in abstracting and indexing of current scientific literature. Outstanding benefits including tuition assistance. Please submit complete resume.

Box 53, SCIENCE

Biophysicist-Electrophysiologist. For research on electrophysiology of vision in large midwestern university. Ph.D. or equivalent. Experience with electrophysiological equipment required. Eye experience not necessary. Salary from $7500, depending on training and experience. Box 56, SCIENCE. 3/18, 25

Medical Technician, male or female, B.S. preferred, research laboratory. Paraffin sectioning, H and E plus special staining. Some experience required. Dr. J. Christensen, St. Barnabas Medical Center, High St., Newark, N.J. 3/11, 18

Microbiologist. M.S. or Ph.D. for chief post in a three-man laboratory that services the hospital and Isaac Albert Research Institute, research potential, new facilities, living accommodations, 30 minutes from New York City, good salary plus grant supplementations. Personnel Department, Jewish Chronic Disease Hospital, East 49 Street, Brooklyn 3, N.Y. 3/18, 25

POSITIONS OPEN

Instructorships (3) at West Coast urban university—teaching in general biology, general zoology, general botany, advanced invertebrate zoology, and plant physiology. Research field open, but broad biological background essential and marine interest somewhat preferred. Box 60, SCIENCE. 3/18

(a) **Microbiologist;** M.S., research potential; supervise two in laboratory, chronic disease hospital, affiliated research institute; $7000, plus grant supplementations for research projects; East. (b) **Pharmacologist;** M.D., for clinical investigation; prominent eastern pharmaceutical company; to $13,000. (c) **Biochemist;** M.S., Ph.D., to head busy laboratory section, large Chicago hospital; $8000 up. (d) **Bacteriologist-Immunologist** degree; joint research project, university dental school, affiliated hospital; requires experience bacteriology, serology; excellent opportunity for permanence, advancement; Midwest. (e) **Biochemist;** Ph.D., also consider physiology training; train in-plant visitors in coagulation, related problems; $10,000; prominent eastern research, pharmaceutical corporation. (f) **Pharmacologist;** Ph.D. with sufficient medical study for orientation; $10,000; midwestern unit, well-known company. (Please write for an analysis form. Our 64th year: Founders of the counselling service to the medical profession; serving medicine with distinction for more than half a century.) Science Division, Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash, Chicago. X

Current opening for **Parasitologist,** instructor or assistant professor, for full-time research on parasitic diseases, starting salary $5500-$6400. Also **Chemist or Biochemist,** B.S. or M.S., as research assistant in fundamental studies on muscular dystrophy; will consider either full-time appointment starting at $5200 or two half-time graduate students at $2600. Write Dr. E. A. Tunnicliff, Head, Montana Veterinary Research Laboratory, Bozeman, Montana. 3/11

Pharmacologist, Ph.D. or equivalent, to develop and supervise expanding research program in medicinals. Excellent opportunity, salary commensurate with education and experience. Liberal benefit program. Lloyd Brothers Laboratories, Cincinnati 30, Ohio. X

(a) **Physiologist-Pharmacologist** for research on drugs pertaining to arteriosclerosis; biochemistry background helpful; leading drug manufacturer; $10,000 year up; East. (b) **Clinical Biochemist,** M.S. or Ph.D. degree, to head department of large hospital; Midwest. (c) **Veterinarian-Geneticist** to take charge of farm producing hybrid and inbred mice; around $10,000 year; East. (d) **Botany Faculty** appointment for large university opening new science building; South. (e) **Biochemist** with pharmacology or physiology background to conduct research on drugs and chemicals in relatively new division of established commercial firm; $10,000 year up; East. (f) **Bacteriologist** to supervise product development of vaccines; knowledge of tissue culture production desirable; Midwest. (g) **Biology-Microbiology** faculty appointments at liberal arts and science university; East. (Please write for details; also many other positions available through our nation-wide service.) S3-2 Medical Bureau, Inc., Science Division, Burneice Larson, President, 900 North Michigan Avenue, Chicago. X

Postdoctoral Traineeships in Metabolism and Nutrition. Postdoctoral traineeship in the field of metabolism and clinical nutrition are available in the Department of Biochemistry and Nutrition, University of Pittsburgh. The program is primarily for physicians who have had a minimum of an internship and who are interested in clinical investigation. The stipends begin at $5500 per annum, and appointments may be made for a period of 1 to 3 years beginning 1 July 1960. Please apply to Dr. Robert E. Olson, Professor and Head, Department of Biochemistry and Nutrition, University of Pittsburgh, Pittsburgh 13, Pa. 3/11

Research Associate, Ph.D. for work on endocrine effects on salt balance in lower vertebrates. Appointment immediately, July or September. Write B. T. Scheer, Department of Biology, University of Oregon, Eugene. X

RESEARCH ORGANIC CHEMIST, M.S. or Ph.D. Pharmaceutical experience in synthetics and natural products desired. Eastern United States. Write listing education, work experience, and salary desired.
Box 52, SCIENCE

Writer for weekly journal to report developments in national and international affairs that bear on science. Familiarity with the Washington scene helpful, background in natural science helpful, experience as a journalist necessary. Position and salary open. State qualifications in a letter to Editor, SCIENCE, 1515 Massachusetts Avenue, NW, Washington 5, D.C. ew

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Predoctoral and Postdoctoral Training Programs in Anatomy are available for qualified students. Stipends range from $1800 to $4200 for undergraduates, starting at $6000 for postdoctoral fellows. Tuition and a modest travel allowance are provided for. The department has ten full-time faculty members, all with active research programs. Training may include electron microscopy, tissue culture methods, phase cinematography, autoradiography, histochemistry, medical genetics, experimental endocrinology, and modern techniques for investigation of the nervous system. The program includes opportunities for training at other divisions of the university in accord with the desires and best interests of the student. For further information please write to the Chairman, Department of Anatomy, The University of Texas Medical Branch, Galveston, Texas. 3/25; 9/2; 10/7

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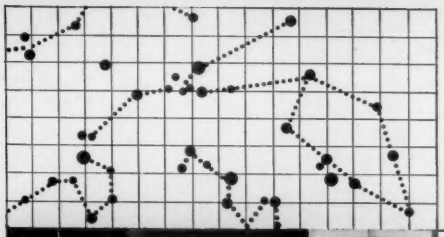

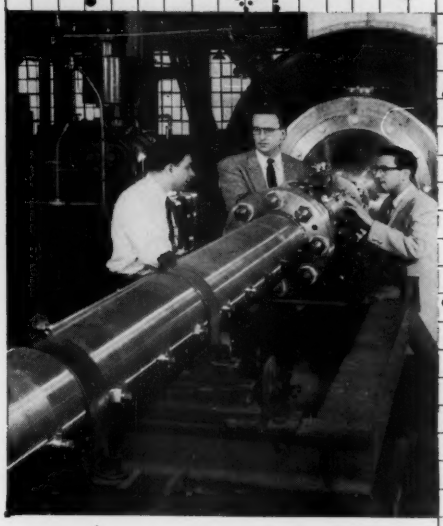

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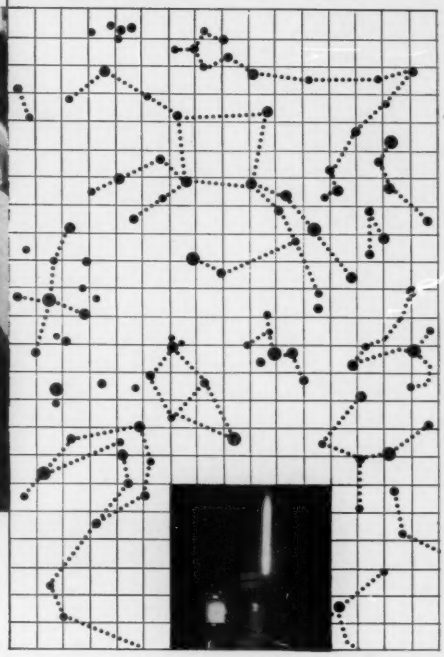

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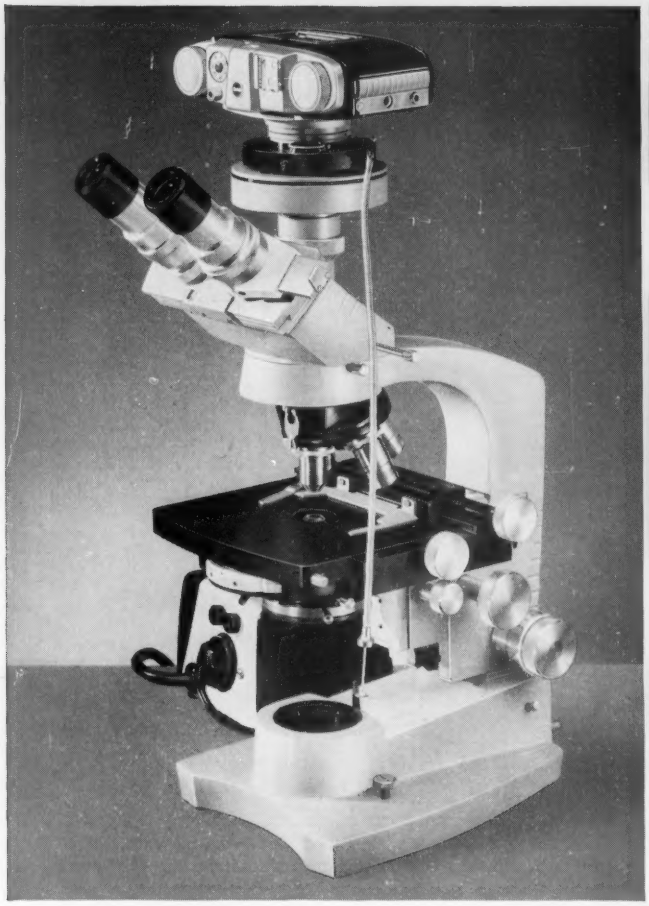

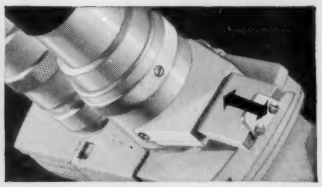

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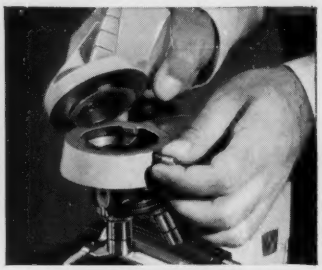

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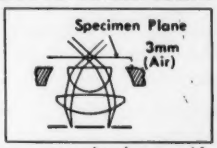

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